PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-241125
(43)Date of publication of application : 11.09.1998

(51)Int.CI. G11B 5/39
G11B 5/31

(21)Application number : 09-342521
(22)Date of filing : 12.12.1997

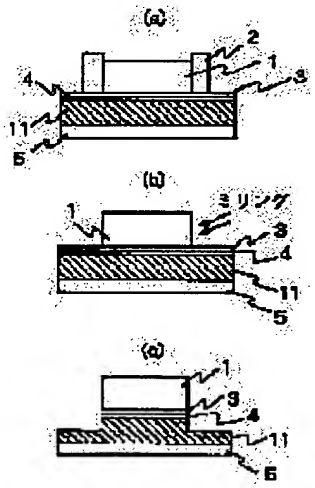
(71)Applicant : HITACHI LTD
(72)Inventor : KOMURO MATAHIRO
HOSHINO KATSUMI
YOSHIDA NOBUO
NAKAMURA ATSUSHI
SHIMIZU NOBORU
HARA YOSHINORI
KAWABE TAKASHI
OKADA TOSHIHIRO
SANO MASAAKI
MARUYAMA YOJI
FUYAMA MORIAKI
FUKUI HIROSHI

(30)Priority

Priority number : 08344941 Priority date : 25.12.1996 Priority country : JP
08344995 25.12.1996 JP

(54) THIN FILM MAGNETIC HEAD AND RECORDING/REPRODUCING SEPARATION TYPE MAGNETIC HEAD AND MAGNETIC RECORDING/ REPRODUCING APPARATUS USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To prevent deterioration of recording performance in high frequency recording by forming a magnetic cap with a magnetic film of two or more layers and by setting a specific resistance of a magnetic film of at least single layer of magnetic film to the value higher than that of the other magnetic film.
SOLUTION: Under the lower magnetic film 5 working as an upper shielding film, MR and GMR film are provided as a reproducing head. At a part 11 of this lower magnetic film, a non-magnetic film having a high specific resistance (80μΩcm or higher) is formed by the sputtering method, etc., as a gap film 4. As a magnetic film satisfying this characteristic, a film having a high specific resistance can be obtained by simultaneously adding oxygen, nitrogen and an element having intensive affinity thereto, for example, Fe, CoFe alloy, etc. On this film having high specific resistance, a lower layer film 3 is formed, a resist frame 2 is formed thereon to form an



upper magnetic film 1 by the plating method. Here, drop of recording performance can be controlled in the high frequency range by setting the thickness of high specific resistance film to 0.5 to 3 times the thickness of the gap film.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The thin film magnetic head to which the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and specific resistance of the magnetic film of at least one layer of a magnetic film is characterized by being [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films at least in the thin film magnetic head equipped with the up magnetic film and the lower magnetic film through the nonmagnetic magnetic-gap film.
[Claim 2] The thin film magnetic head characterized by being higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film in the thin film magnetic head equipped with the up magnetic film and the lower magnetic film through the nonmagnetic magnetic-gap film.
[Claim 3] The aforementioned magnetic film with higher specific resistance according to claim 1 or 2 is the thin film magnetic head characterized by saturation magnetic flux density being smaller than other magnetic films.
[Claim 4] The thin film magnetic head characterized by for the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film having a convex configuration, and a part of aforementioned up magnetic film and lower magnetic film [at least] having the specific resistance of 50 or more microomegacm in the thin film magnetic head equipped with the up magnetic film and the lower magnetic film through the nonmagnetic magnetic-gap film.
[Claim 5] In the record reproduction discrete-type magnetic head which was able to prepare magnetic shielding for the recording head which writes in information, and the reproducing head to read the aforementioned recording head It has an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. The record reproduction discrete-type magnetic head which the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and is characterized by the specific resistance of the magnetic film of at least one layer of a magnetic film being [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films at least.
[Claim 6] In the record reproduction discrete-type magnetic head in which the recording head which writes in information, and the reproducing head to read were prepared through magnetic shielding the aforementioned recording head It has an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. The record reproduction discrete-type magnetic head characterized by being higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film.
[Claim 7] It is the record reproduction discrete-type magnetic head characterized by to equip

the aforementioned recording head with an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film in the record reproduction discrete-type thin film magnetic head in which the recording head which writes in information, and the reproducing head to read were prepared through magnetic shielding, for the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film to have a convex configuration, and for a part of aforementioned up magnetic film and lower magnetic film [at least] to have the specific resistance of 50 or more microomegacm.

[Claim 8] In the record reproduction discrete-type magnetic head in which the recording head which writes in information, and the reproducing head to read were prepared through magnetic shielding the aforementioned recording head It has an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. At least, the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and the specific resistance of the magnetic film of at least one layer of a magnetic film is [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films, Are higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film, It consists of either of the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film having a convex configuration, and a part of aforementioned up magnetic film and lower magnetic film [at least] having the specific resistance more than 50micro omegacm. the aforementioned reproducing head And a ferromagnetic, Stick to this ferromagnetic and the antiferromagnetic substance which makes the aforementioned ferromagnetic discover the 1 direction anisotropy is included. The record reproduction discrete-type magnetic head to which a part of portion [at least] which a part of aforementioned antiferromagnetic substance [at least] sticks to the aforementioned antiferromagnetic substance of the aforementioned ferromagnetic by consisting of a Cr-Mn alloy is characterized by the bird clapper from Co or Co alloy.

[Claim 9] The thin film magnetic disk which records information. The rotation means of this thin film magnetic disk, and the recording head which is prepared in a float-type slider and writes in information and the reproducing head to read. It is the magnetic recording medium equipped with the above. the aforementioned recording head It has an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. At least, the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and the specific resistance of the magnetic film of at least one layer of a magnetic film is [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films, Are higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film, And it is characterized by the bird clapper from either of the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film having a convex configuration, and a part of aforementioned up magnetic film and lower magnetic film [at least] having the specific resistance of 50 or more microomegacm.

[Claim 10] The thin film magnetic disk which records information. The rotation means of this thin film magnetic disk, and the recording head which is prepared in a float-type slider and writes in information and the reproducing head to read. It is the magnetic storage regenerative apparatus equipped with the above. the aforementioned recording head It has an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. At least, the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and the specific resistance of the magnetic film of at least one layer of a magnetic film is [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films, Are higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower

magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film, It consists of either of the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film having a convex configuration, and a part of aforementioned up magnetic film and lower magnetic film [at least] having the specific resistance more than 50micro omegacm. the aforementioned reproducing head And a ferromagnetic, It sticks to this ferromagnetic, a part of aforementioned antiferromagnetic substance [at least] consists of a Cr-Mn alloy including the antiferromagnetic substance which makes the aforementioned ferromagnetic discover the 1 direction anisotropy, and a part of portion [at least] stuck to the aforementioned antiferromagnetic substance of the aforementioned ferromagnetic is characterized by **** from Co or Co alloy.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the suitable new thin film magnetic head, the record reproduction discrete-type magnetic head, and a magnetic storage regenerative apparatus, when starting the magnetic recording medium used for a computer, an information processor, etc., especially realizing high-density record.
[0002]
[Description of the Prior Art] Semiconductor memory and magnetic-substance memory are mainly used for the storage (record) equipment of information machines and equipment. Semiconductor memory is used for internal storage from a viewpoint of the access time, and magnetic-substance memory is used for a mass and nonvolatile viewpoint shell external recording device. The mainstream of magnetic-substance memory is in a magnetic disk and a magnetic tape today. As for the record medium used for these, the magnetic thin film is formed on aluminum substrate or the tape made of a resin. in order to write magnetic information in this record medium -- electromagnetism -- the function part which has a conversion operation is used Moreover, in order to reproduce magnetic information, the function part using the magnetic-reluctance phenomenon, the huge magnetic-reluctance phenomenon, or the electromagnetic-induction phenomenon is used. These function parts are prepared in the parts for I/O called magnetic head.
[0003] The magnetic head and a medium move relatively, magnetic information is written in the arbitrary positions on a medium, and it has the function which reproduces magnetic information electrically as occasion demands. When a magnetic disk unit is stated to an example, the magnetic head writes in magnetic information and consists of the section and the reproduction section to read. The write-in section wraps a coil and this up and down, and consists of magnetic poles combined magnetically. The reproduction section consists of electrodes for passing a constant current in the magnetoresistance-effect element section and this element section, and detecting resistance change. The magnetic shield layer is prepared between the section write-in [these] and the reproduction section. Moreover, these function parts are formed through the ground layer on the magnetic-head main part.
[0004] record -- electromagnetism -- reproduction of magnetic information is possible also by detecting the electromagnetic-induction current guided to the coil which the magnetoresistance effect was used for a conversion operation and reproduction, and was prepared in the write-in section In this case, record and reproduction can be performed by one function part.
[0005] The performance of storage has indispensable shortening and large-capacity-izing of the access time, in order to be decided by the speed and storage capacity at the time of input/output operation and to heighten product competitive strength. Moreover, the miniaturization of the demand of small-and-light-izing of information machines and equipment to storage is becoming important in recent years. In order to satisfy these demands, the magnetic storage which writes in many magnetic information and can be reproduced needs to be developed in a single record medium.
[0006] In order to satisfy this demand, it is necessary to raise the recording density of

equipment. In order to realize high-density record, it is necessary to turn the size of a magnetic domain to write in minutely. It is realizable by raising the frequency of the write-in current which narrows width of face of a write-in magnetic pole, and is passed in a coil to this.
[0007]
[Problem(s) to be Solved by the Invention] In order to realize high recording density, resolution of the reproducing head is high, and in a recording head, in order to make the magnetic-flux leakage in the pole tip into the minimum, it is necessary to narrow gap length and the width of recording track as mentioned above. If gap length and the width of recording track are narrowed, the magnetic-flux intensity between the pole tips will decrease. The reproduction section and the Records Department are combined and applied [produce and] in the combined head which prepared MR and the GMR film in the reproduction section. The shield film of the reproduction section and the lower magnetic film of the Records Department are made to serve a double purpose. A manufacture process is simplified by this and alignment is possible on the same suspension. A side fringe and a RF property pose a problem by the ** truck recording head, and the minimum width of recording track is determination ********** by the former side fringe magnetic field. The problem of a side fringe magnetic field can prevent a lower magnetic film to some extent by forming a notch and the pedestal pole tip. That is, on the JP,7-262519,A specifications, in order to reduce a side fringe, it has the pedestal in the pole tip section. Moreover, the material of a high saturation magnetic moment and the 2nd shield layer are explained to the pedestal pole tip layer as the material of the hyposaturation moments, such as a permalloy. It is shown that this description forms a lower magnetic film from two-layer [of high saturation / hyposaturation magnetic moment]. However, the specific resistance of a magnetic film is not indicated at all. Therefore, if high-frequency record is taken into consideration, it cannot be satisfied with the above-mentioned invention, and specific resistance and saturation magnetic flux density will serve as important requirements.
[0008] moreover -- according to the above-mentioned conventional technology -- magnetic pole width of face -- 2.5 micrometers up to -- narrowing and raising frequency to about 90MHz -- 2Gb/inch2 recording density of a class is realized -- things can be carried out However, it became clear that the problem it is described below that promotes the further densification arises, and a limitation arises in densification.
[0009] This problem can be divided roughly into the problem involved in the manufacturing technology for narrowing magnetic pole width of face, and the magnetic problem produced by having narrowed magnetic pole width of face. First, the problem involved in a manufacturing technology is described. The magnetic pole which constitutes a magnetic gap has the need of generating the magnetic field which is needed in order to reverse magnetization of a record medium (it being made revealing). This magnetic field needs to be decided with the magnetic parameter called coercive force of a record medium, and needs to strengthen the medium for high-density record in recent years. Therefore, since a strong magnetic field is drawn, volume of a magnetic pole portion cannot be reduced. That is, even if it narrows magnetic pole width of face, thickness of a magnetic pole cannot be made thin.
[0010] The material generally used as magnetic pole material is a nickel-Fe alloy. Reactant dry etching is difficult for this material. For this reason, the magnetic pole of a thick film cannot be formed. Then, the galvanizing method is used for formation of a magnetic pole.
[0011] By the galvanizing method, beforehand, the mask of the fields other than a magnetic pole is carried out by the resist pattern, and nickel-Fe is alternatively grown up only into the magnetic pole portion which the electrode for plating exposes. Therefore, in order to form a detailed magnetic pole pattern 2 micrometers or less, it is necessary to form a resist pattern by width of face of 2 micrometers or less beforehand.
[0012] By the way, in order to maintain the function as a mask at the time of plating, it is necessary to carry out thickness of a mask pattern more than plating height. The mask pattern for plating which receives restrictions of these width of face and height is formed by the contiguity exposing method. However, the resolution limit in this method is about 2 micrometers (when thickness is set to about 5 micrometers), and cannot form the pattern not more than this (the expensive manufacture methods, such as an X-ray lithography method, are not taken into

consideration). For this reason, with a conventional method, there is a problem which cannot manufacture the magnetic head for high-density record.
[0013] Furthermore, in the structure of the above-mentioned magnetic head, if magnetic pole width of face is narrowed, it is known well that the magnetic-path resistance near the gap will increase. Magnetic flux flows from an up magnetic film to a lower magnetic film, a required magnetic field stops occurring from the gap section, and a problem arises from this influence, so that magnetic pole width of face is narrowed.
[0014] Moreover, in order to realize high-density record, the problem to which it will write if write-in frequency is raised, and efficiency falls arose. It turns out that the eddy current tends to generate this problem in the magnetic pole section, and the increase of magnetic-path resistance and write-in efficiency fall under this influence.
[0015] As a cause which the eddy current generates, the 1st being able to apply only a metal membrane to a magnetic gap and the 2nd reason are that it cannot form a magnetic path by a high resistance film, an amorphous film, etc. with little generating of the eddy current. Generating of the eddy current is a problem also common to the conventional magnetic head which produces a magnetic pole by the galvanizing method about the fault which cannot form a magnetic path with a few high resistance film, a few amorphous film, etc.
[0016] The purpose of this invention is to offer the thin film magnetic head, record reproduction discrete-type MAG, and magnetic-storage head which formed the magnetic film of high specific resistance in the pole tip partially, in order to prevent degradation of the record performance in RF record.
[0017]
[Means for Solving the Problem] In the thin film magnetic head which this invention equipped with the up magnetic film and the lower magnetic film through the nonmagnetic magnetic-gap film At least, the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and the specific resistance of the magnetic film of at least one layer of a magnetic film is [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films, Are higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film, And the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film have a convex configuration, and a part of aforementioned up magnetic film and lower magnetic film [at least] are characterized by 50 or more microomegacm [either / of having the specific resistance of 80 or more microomegacm preferably] of bird clappers.
[0018] In the record reproduction discrete-type magnetic head in which the recording head in which this invention writes information, and the reproducing head to read were prepared through magnetic shielding the aforementioned recording head It has an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. At least, the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and the specific resistance of the magnetic film of at least one layer of a magnetic film is [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films, Are higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film, And the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film have a convex configuration. It consists of either of a part of aforementioned up magnetic film and lower magnetic film [at least] having the specific resistance of 50 or more microomegacm. further the aforementioned reproducing head A ferromagnetic and the antiferromagnetic substance which it sticks [antiferromagnetic substance] to this ferromagnetic and makes the aforementioned ferromagnetic discover the 1 direction anisotropy are included. A part of aforementioned antiferromagnetic substance [at

least] consists of a Cr-Mn alloy, and a part of portion [at least] stuck to the aforementioned antiferromagnetic substance of the aforementioned ferromagnetic is characterized by the bird clapper from Co or Co alloy.
[0019] The thin film magnetic disk with which this invention records information, and the rotation means of this thin film magnetic disk, The record reproduction discrete-type magnetic head which has the recording head which is prepared in a float-type slider and writes in information, and the reproducing head to read, A move means to support the aforementioned float-type slider and to access to a thin film magnetic disk is provided, and the aforementioned magnetic disk is 4000rpm at the time of record and reproduction. In the magnetic storage whose record frequency it rotates above and is 45MHz or more The aforementioned recording head is equipped with an up magnetic film and a lower magnetic film through a nonmagnetic magnetic-gap film. At least, the aforementioned magnetic-gap portion is constituted by the magnetic film more than two-layer, and the specific resistance of the magnetic film of at least one layer of a magnetic film is [of the aforementioned up magnetic film and a lower magnetic film] higher than the specific resistance of other magnetic films, Are higher than the specific resistance of the 2nd magnetic film to which the specific resistance of the 1st magnetic film of the aforementioned up magnetic film and a lower magnetic film which the aforementioned magnetic-gap portion was constituted at least by the magnetic film more than two-layer, and is separated from the aforementioned gap film touched the magnetic-gap film, And the aforementioned magnetic-gap portions of the aforementioned lower magnetic film and an up magnetic film have a convex configuration. It consists of either of a part of aforementioned up magnetic film and lower magnetic film [at least] having the specific resistance of 50 or more microomegacm. further again the aforementioned reproducing head A ferromagnetic and the antiferromagnetic substance which it sticks [antiferromagnetic substance] to this ferromagnetic and makes the aforementioned ferromagnetic discover the 1 direction anisotropy are included. A part of aforementioned antiferromagnetic substance [at least] consists of a Cr-Mn alloy, and a part of portion [at least] stuck to the aforementioned antiferromagnetic substance of the aforementioned ferromagnetic is characterized by the bird clapper from Co or Co alloy.
[0020] As for the recording head concerning this invention, a lower magnetic film serves as a shield film with the reproducing heads, such as MR and GMR. (Recording head) A nonmagnetic gap film is formed between an up magnetic film and a lower magnetic film, and creates a part of lower magnetic film or up magnetic film by dry processes, such as the sputtering method and a vacuum deposition method. It has the specific resistance of 80 or more microomegacm preferably, and is the frame of a plating film SiO2 It forms, the width of face determines the width of recording track of record, and the width of recording track is 1.5 micrometers. It is desirable that it is the following.
[0021] The magnetic film which has the high specific resistance more than 80micro omegacm is saturation-magnetic-flux-density 1.5T. It is above and it is desirable to process the magnetic-film edge of the gap film upper and lower sides by RIE, and to arrange the width of face of the magnetic film of the gap film upper and lower sides.
[0022] Furthermore, it is desirable that the absolute value of the magnetostriction constant of the magnetic film which has the high specific resistance of 80 or more microomegacm carries out to 1x10 to seven or less, and it is a part of 0.5 micrometers of a vertical magnetic film. It is desirable to form the above thickness by the high specific resistance film. It is desirable that some directions of the magnetic film of high specific resistance are larger than a part of magnetic film of low specific resistance [width of face / of the magnetic film seen from the surfacing side].
[0023] While field recording density increases, it is in the inclination which the record frequency of a magnetic disk unit also increases. If record frequency exceeds 100MHz, eddy current loss of a magnetic film will become large, and a recording characteristic will deteriorate. 2 micrometers of width of recording track, 0.3 micrometers of gap lengths It is 1.0T about the saturation magnetic flux density of a magnetic film. When it carries out, magnetic field strength becomes high, so that it is high, and the specific resistance of the magnetic film at the time of high-frequency conditions 100MHz or more has 80 or more good microomegacm. This calculation

result shows that it is necessary to use the film of high specific resistance for the magnetic film of a part of magnetic pole, especially an edge. Furthermore, in order to reduce heat treatment among a magnetic field added to reduction of an after [a light] noise, and the magnetic film at the time of recording head production, it is desirable to make the magnetostriction constant of a magnetic film small to 1x10 to seven or less. Moreover, the saturation magnetic flux density of a magnetic film is 1.5T, in order to make thickness of a magnetic film thin and to prevent saturation further. Considering as the above high thing is desirable.

[0024] If the head structure formed into the present mass production is compared and estimated as the case of the structure which a surfacing side furthermore shows to drawing 3 , it is clear that making high Bs of the magnetic film 5 which touched the gap film 4, and a magnetic film 1, and making high specific resistance rho of the magnetic film 5 which is separated from a gap film, and a magnetic film 12 contributes to high magnetic field inclination and a RF property. If all the above-mentioned magnetic films are able to produce by high Bs, Quantity rho, low [lambda], low Hk, and the monolayer, magnetic field strength is high, and although a recording head with the good RF property is obtained, it is difficult [it] to mass-produce the magnetic film of such a property. Then, the magnetic film near a gap can offer the magnetic head with a good recording characteristic using the material which can be mass-produced by making into the magnetic material of Quantity rho all the all [a part or] that is separated from a gap in a material high Bs and low [rho]. For example, it is difficult to produce thickly (about 3 micrometers) the film which consists of 3d transition metals which are the high specific resistance which satisfies these properties, and the film which has high saturation magnetic flux density, and have a small magnetostriction constant (an absolute value is 1x10 to seven or less preferably) by the galvanizing method. However, if the sputtering method is used, it is possible for the magnetic film which satisfies these properties to add oxygen and nitrogen in Fe system, a FeCo system, or a FeNiCo system, and to control a magnetostriction constant using other alloy elements. or -- if the sputtering method is used -- the ferromagnetic alloy film and aluminum 2O3 of Fe system, a FeCo system, or a FeNiCo system, and SiO2 etc. -- by making it a multilayer with an oxide, or a mixed phase film, it is possible to make the eddy current small Since it is more difficult than the case where the galvanizing method is applied to constitute only from a film which created these magnetic films by the sputtering method, and to form in a ** truck (preferably 1.5 micrometers henceforth) further, the portion (about 3 times of gap length) in the up magnetic film (UP) created on a gap film which contacts a gap film at least has the effective method of producing by the galvanizing method.

[0025] The magnetic field strength which is one of the performances of a recording head becomes high rather than the direction which sets the portion near the gap in a core to Bs sets to high Bs the portion which is separated from a gap. Since the magnetic properties of the magnetic film near the surfacing side side of a gap affect for a performance strongly especially, the structure which sets to high Bs the portion (near a gap) which contacted the gap film from the surfacing side side, and makes portions other than a high Bs film Quantity rho (low Bs is sufficient) is effective as recording head structure of the ** width of recording track (1.5 micrometers or less). When it sees from a surfacing side, it is necessary to form in the width of face corresponding to the value of the width of recording track the width of face of the magnetic film which touches a gap film. When forming a magnetic film by the galvanizing method, the interval of a plating frame can determine, the width of face, i.e., the width of recording track, of a plating film, and it is 0.3-1.5 micrometers. The plating film of width of face can also be formed. Moreover, by the galvanizing method, since the alloy film of Fe, nickel, Co(es) and these 2 yuan, or 3 yuan can be formed easily and the film (a CoNiFe alloy, NiFe alloy) of high Bs (more than 1.5T) can also be formed, a plating film is applicable to a part of magnetic core in contact with the gap film (a gap film near [or]) which determines the width of recording track. the case where the specific resistance of this plating film is constituted only from an above-mentioned ferromagnetic element -- at most -- 50microomegacm -- it is -- 3d transition-metals element -- adding -- Bs1.3T rho in the case of the above film -- about 60 microomegacm and a semimetal element -- adding -- Bs0.9T In the case of the above plating film, rho is set to about 100 microomegacm. A high Bs film is required for 1 of drawing 3 , or the magnetic film of 5 like

the above-mentioned explanation, and if rho of the magnetic film of 12 or 5 is a high value, it is not necessary to make rho of a magnetic film (1 and 5) high. That is, the rate for which the quantity rho material accounts for volume rather than high Bs film (low [rho]) material increases by the volume of magnetic pole material.
[0026] it is shown in drawing 1 -- as -- a part of lower magnetic film 11 -- the sputtering method -- high specific resistance (80 or more microomegacm) -- high -- 1xten to seven or less film is created preferably as Bs>1.5T and a magnetostriction constant (in absolute value), 0.1 or a 0.2-micrometer nonmagnetic membrane is formed by the sputtering method on it, and it considers as the gap film 4 The ground 3 of a plating film is formed by the sputtering method on it. This ground 3 can also be considered as a high specific resistance film. The resist frame 2 is formed on a ground 3, and an up magnetic film is produced by the galvanizing method. the width of recording track -- the interval of a frame -- being decided -- the frame galvanizing method -- 0.5 micrometers up to -- it is checking that it is producible without composition change Furthermore, it is possible to reduce a side fringe by the dry etching methods, such as milling and the RIE (reactive etching) method, by using the up magnetic film 1 as a mask by removing a part of ground 3, gap film 4, and lower magnetic film (up shield film of MR or GMR) without re-adhesion. The thickness of a high specific resistance film is 0.5 of the thickness of a gap film. Or it is considering as 3 or more times, and the magnetic field strength in high frequency, i.e., record performance degradation, can be suppressed. A record performance can be raised by producing the film (the lower magnetic film 5 and up magnetic film 1) of the upper and lower sides of a gap 4 by the galvanizing method, and producing a high specific resistance film apart from drawing 1 , by the thick film which is larger width of face than the width of face of the lower magnetic film 5 or the up magnetic film 1. For example, the thing of a frame for which the high specific resistance film 12 is produced by the sputtering method a top and on the up magnetic film 1 in part is possible. In this case, gap films are conductive nonmagnetic membranes (Cr alloy etc.). moreover, a frame -- SiO2 etc. -- it is an oxide, and like drawing 1 , there is no frame removal process and it has the producing method a frame remains in a surfacing side as it is You may use a resist for a plating frame. Although drawing 4 is drawing 1 and analogous structure, thin high specific resistance and the high Bs film 12 are formed with plating also on a gap 4. Thickness is 0.5 of a gap. Or it is 3 times, and plating is also possible, while the effect of high specific resistance will appear in a record performance clearly, if it is the thickness of this range. This high specific resistance plating film 12 is a ferromagnetic alloy film containing elements, such as P, B, and O.
[0027] Since it is difficult, producing a film high Bs, low Hk, Quantity rho, and low [lambda] by these galvanizing methods can also use some up shield films 11 and a part of up magnetic film 12 as a high specific resistance (80 or more microomegacm) film using the sputtering method, as shown in drawing 5 .
[0028] In drawing 5 , the magnetic film 13 and magnetic film 14 of the gap film upper and lower sides are produced by the galvanizing method. The Bs of the above-mentioned magnetic films 13 and 14 is higher than Bs of the high specific resistance film (some shield films 11 and a part of up magnetic film) produced by the sputtering method etc. By making high Bs of the magnetic film near a gap film, the magnetic field strength from a gap becomes high, and a RF property is improved by the quantity rho magnetic film (11 12) produced by the sputtering method. Moreover, as shown in drawing 5 , it is the feature that it is narrower than the width of face of the magnetic film (11 and 12) which is further separated from the gap film 14 (when it sees from a surfacing side), and, with such structure, the width of face of a magnetic film 13, the gap film 14, and a magnetic film 14 can enlarge the magnetic field inclination of a recording head.
[0029] The recording head in this invention sandwiches and constitutes the magnetic film of the gap section from a facing magnetic pole which has a convex configuration mutually as mentioned above.
[0030] Moreover, the thing for which especially an up magnetic pole has a convex configuration, and forms heights toward a lower magnetic pole about the magnetic pole configuration at the nose of cam of the magnetic core which the above-mentioned magnetic head exposes in a record medium and the field to approach, While considering as the composition with which the

upper part and a lower magnetic pole are made into a convex configuration and which heights face mutually While considering as the composition with which to arrange so that the width-of-face center of the heights of an up magnetic pole and the width-of-face center of the heights of a lower magnetic pole may lap on the same line, respectively, the upper part, and a lower magnetic pole are made into a convex configuration and which heights face mutually, it is desirable to consider as either of making the height of heights low compared with the width of face of heights.

[0031] It is desirable to manufacture the recording head concerning this invention according to the following process.

[0032] (1) The process which carries out the laminating of the insulating nonmagnetic membrane, and carries out the laminating of the material used as the heights which constitute a part of up magnetic pole further after carrying out the laminating of the lower magnetic pole material on magnetic-head ground structure.

[0033] (2) The process which forms a resist pattern in the field which uses the lithography method and is equivalent to the heights of an up magnetic pole on the above-mentioned laminated structure.

[0034] (3) The process which forms heights in a lower magnetic pole by **********ing an insulating nonmagnetic membrane and a lower magnetic pole on a mask in the member used as a part for the heights of the above-mentioned resist pattern and an up magnetic pole.

[0035] (4) The process which carries out a laminating by the thickness which carries out the laminating of nonmagnetic and the insulating film to the whole surface, or exceeds heights to fields other than heights after forming the member which serves as heights in the upper part and a lower magnetic pole.

[0036] (5) The process which forms the up magnetic pole which makes heights a valley by forming the remaining members which constitute an up magnetic pole member.

[0037] (6) The process which exposes a part of member used as heights to a flattening side while carrying out flattening processing of nonmagnetic and the insulating film.

[0038] (7) The process which forms the remaining members which constitute an up magnetic pole member.

[0039] Or the reproducing head in this invention (reproducing head) consists of the above-mentioned magnetoresistance-effect type element, and, as for a soft-magnetism film and a ferromagnetic, the magnetic field of 0 - 180 degrees may change to the magnetic film from which the magnetic film from which the direction of a magnetic field leans 90 degrees mutually, and serves as a free layer by the magnetic field from a record medium serves as the fixed bed.

[0040] In this invention, the magnetic recording medium which carried the magnetoresistance-effect element using the huge magnetoresistance effect as a means corresponding to high recording density in the magnetic head is used.

[0041] There is development of the antiferromagnetism film which carries out a direct laminating to a ferromagnetic and produces switched connection bias as one of the technical problem of the. Let the principal components of the aforementioned antiferromagnetism film be chromium and manganese in the first place by this invention as a The means for solving a technical problem. Two or more elements chosen one of a platinum group, gold, silver, copper, nickel, and the cobalt or from these are added, in order to make the property good, the second is made to increase a lattice constant for this structure with a body centered cubic structure, and the size of a switched connection magnetic field and the temperature characteristic are improved to it. In order to increase the size of the 1 direction anisotropy generated [third] between a ferromagnetic and the antiferromagnetic substance, it considers as the cobalt alloy which composed the ferromagnetic as cobalt and composed cobalt the principal component. When using as a soft magnetic material, its Co-Fe-nickel alloy is good, and composition of a cobalt alloy has a good Co-Pt alloy, when using as a high coercive force material. It heat-treats, in order to arrange [the fourth and] the direction of an one direction anisotropy. To the fifth, especially, although it is effective in a spin bulb type magnetoresistance-effect film, the ferromagnetic layer which touches an antiferromagnetism layer is made into the layered product of three layers or the ferromagnetic layer beyond it, and sum total thickness is set to 3nm or

more, and the heat deterioration of properties, such as the magnetoresistance effect, is prevented.
[0042] In this invention, in the magnetic recorder and reproducing device which made the reproduction section such material composition and the magnetoresistance-effect element which used magnetic properties, short [the record wavelength recorded on high recording density, i.e., a record medium,], the width of face of a recording track can realize narrow record, can obtain sufficient reproduction output, and can keep record good.
[0043] That is, the magnetoresistance-effect element concerning this invention realizes fixed bias or vertical bias with the antiferromagnetic substance of a chromium machine alloy, or the antiferromagnetic substance and the cobalt system ferromagnetic of Mn machine alloy. Moreover, the ferromagnetic layer which touches an antiferromagnetism film can be constituted like the layered product of a three or more-layer ferromagnetic layer, for example, Co/NiFeCr/Co, a spin bulb type magnetoresistance-effect element with high resistance rate of change, a big switched connection magnetic field, and high thermal stability can be realized by setting preferably 3nm or more of the sum total thickness to 3-20nm, and the magnetoresistance-effect element and the magnetic head which have sensitivity and reliability with this good result, and the high magnetic recording medium of recording density can be obtained.
[0044] The reproducing head concerning this invention is a magnetometric sensor containing a ferromagnetic and the antiferromagnetic substance stuck to a ferromagnetic, a part of aforementioned antiferromagnetic substance [at least] which makes the aforementioned ferromagnetic discover the 1 direction anisotropy is a Cr-Mn alloy, and a part of portion [at least] stuck to the aforementioned antiferromagnetic substance of the aforementioned ferromagnetic consists of Co or a Co alloy. Moreover, the reproducing head concerning this invention has the 1st and 2nd magnetic layers of a ferromagnetic divided by the non-magnetic metal layer, and the antiferromagnetism layer prepared in contact with either of these magnetic layers. When an impression magnetic field is zero, the magnetization direction of the 1st magnetic layer of the aforementioned ferromagnetic A means to have a means to have the direction which intersects perpendicularly to the magnetization direction of the 2nd aforementioned layer, and to fix the magnetization direction of the 2nd magnetic layer of the above, or not to have, and to make the aforementioned magnetoresistance-effect element produce current, It is characterized by having a means to detect electric resistance change of the aforementioned magnetic-reluctance sensor produced by rotation of the 1st-layer [aforementioned] magnetization as a function of the magnetic field detected, for the above 1st and the 2nd magnetic layer being Co or Co alloy, and the aforementioned antiferromagnetism layer being a Cr-Mn alloy.
[0045] As for the aforementioned magnetoresistance-effect element, it is desirable to have the composition of a soft-magnetism layer / non-magnetic layer / ferromagnetic layer / antiferromagnetism layer, and for magnetization of the aforementioned soft-magnetism layer to rotate according to an external magnetic field, and for a relative angle with magnetization of the aforementioned ferromagnetic layer to change, and to have a magnetoresistance-effect operation.
[0046] The aforementioned Cr-Mn alloy has a desirable thing containing 30 - 70 atom %Mn, and 0.1 -30 atom % content of at least one chosen from the group which consists of Co, nickel, Cu, Ag, Au, Pt, Pd, Rh, Ru, Ir, Os, and Re further can be done by the sum total content.
[0047] The aforementioned ferromagnetic layer consists of a layered product which has Co or Co alloy thin film to both sides through Co, Co alloy, or nickel alloy thin film. the aforementioned antiferromagnetism layer A Cr-Mn alloy Or it is a Cr-Mn-X alloy and it is desirable that it is at least one chosen from the group which Above X becomes from Co, nickel, Cu, Ag, Au, Pt, Pd, Rh, Ru, Ir, Os, and Re, and a sum total content is 0.1 to 30 atom %.
[0048] As for the aforementioned magnetic storage, it is desirable to perform the magnetization process cooled while equipment environmental temperature's driving above 100 degrees C and the aforementioned magnetometric sensor heat at temperature lower than the blocking temperature to which the 1 direction anisotropy generated in the laminating composition of the

aforementioned ferromagnetic layer and an antiferromagnetism layer and the magnetic field generated from the current to which it flows to a magnetometric sensor being almost same directions, and the aforementioned 1 direction anisotropy disappear and impress a magnetic field.

[0049] As for this invention, what has at least one of the following requirements is desirable.
[0050] The saturation magnetic flux density of the ferromagnetic layer of the above second is smaller than the aforementioned first and second saturation magnetic flux density of a ferromagnetic layer.
[0051] The aforementioned ferromagnetic layer thickness should be 3nm - 20nm.
[0052] At least one as which the ferromagnetic layer of the above second was chosen from the group which 50 to nickel 85 atom %, 15 to iron 20 atom %, and the remainder become from chromium, vanadium, titanium, copper, gold, silver, a platinum group, a tantalum, niobium, a zirconium, and a hafnium is contained 35% or less in total, and saturation magnetic flux density is 0.9. It is below a tesla.
[0053] The saturation magnetic flux density to which either [of a ferromagnetic layer / at least] the aforementioned first or the third make Co a principal component is 1.0. The magnetic substance more than a tesla to bird clapper.
[0054] The aforementioned Cr alloy antiferromagnetism film is the crystal lattice of a body centered cubic structure or CsCl type structure 0.1 Have the structure made distorted in the range of 10% of shells.
[0055] Perform heat treatment which makes the above-mentioned Cr alloy antiferromagnetism film distorted.
[0056] The aforementioned Co alloy consists of Co, nickel, and Fe, the composition is Co30 to 98 atom %, 30 atom [from nickel0] %, and 50 atom [from Fe2] %, and is 95 atom % and 15 atom [from Fe5] % from Co85 especially, or it is 70 atom %, 30 atom [from nickel10] %, and 20 atom [from Fe5] % from Co50.
[0057] The aforementioned Co alloy consists of Co, nickel, Fe, and an alloying element X, the sum total of Co, nickel, and Fe is 70 to 98 atom %, X is 2 to 30 atom %, and Above X should be plural [of Cu, Cr, V, Ti Ta, Nb, Zr, Hf, and a platinum group / any one or plural].
[0058] An oxide film is formed by heat treatment, the thin film coating technology, or ion implantation on the above-mentioned Cr alloy antiferromagnetism film front face, and it is a bird clapper.
[0059] It is the 2nd magnetic layer of the aforementioned ferromagnetic with which an aforementioned means to fix the magnetization direction of the 2nd magnetic layer of the aforementioned ferromagnetic has coercivity higher than the 1st magnetic layer of the aforementioned ferromagnetic.
[0060] Have the antiferromagnetism layer to which an aforementioned means to fix the magnetization direction of the 2nd magnetic layer of the aforementioned ferromagnetic contacts the 2nd magnetic layer of the aforementioned ferromagnetic directly.
[0061] Have the hard ferromagnetism layer to which an aforementioned means to fix the magnetization direction of the 2nd magnetic layer of the aforementioned ferromagnetic contacts the 2nd magnetic layer of the aforementioned ferromagnetic directly.
[0062] The magnetization direction of the thin film layer of each aforementioned ferromagnetic to the direction of the aforementioned current should be appointed to be added to the aforementioned electric resistance change of the aforementioned magnetoresistance-effect element which anisotropy magnetic reluctance produces by rotation of magnetization of the magnetic layer of each aforementioned ferromagnetic.
[0063] The magnetization direction of the thin film layer of each aforementioned ferromagnetic to the direction of the aforementioned current should be appointed to be added to the aforementioned electric resistance change of the aforementioned magnetoresistance-effect element which anisotropy magnetic reluctance produces by rotation of magnetization of the 1st magnetic layer of the aforementioned ferromagnetic.
[0064] Have further a means to produce bias lengthwise [sufficient] to hold the 1st magnetic layer of the aforementioned ferromagnetic in the single domain state.

[0065] Have the antiferromagnetism layer to which an aforementioned means to produce lengthwise bias contacts directly only the edge field of the 1st magnetic layer of the aforementioned ferromagnetic.
[0066] Have the hard ferromagnetism layer to which an aforementioned means to produce lengthwise bias contacts directly only the edge field of the 1st magnetic layer of the aforementioned ferromagnetic.
[0067] Have further a means to produce bias lengthwise [sufficient] to hold the 1st magnetic layer of the aforementioned ferromagnetic in the single domain state.
[0068] Have the antiferromagnetism layer to which an aforementioned means to produce lengthwise bias contacts directly only the edge field of the 1st magnetic layer of the aforementioned ferromagnetic.
[0069] Have the hard ferromagnetism layer to which an aforementioned means to produce lengthwise bias contacts directly only the edge field of the 1st magnetic layer of the aforementioned ferromagnetic.
[0070]
[Embodiments of the Invention]
(Example 1) Drawing 1 - drawing 5 show the structure near the recording head section when seeing the magnetic head from a slide side side. MR and a GMR film are under the lower magnetic film 5 used as an up shield film, and it becomes a reproducing-head portion. As for a substrate, what has small surface irregularity (5nm or less) is desirable.
[0071] As shown in drawing 1 , the film of high specific resistance (80 or more microomegacm) and Bs>1.5T ** is created by the sputtering method or the ion beam sputtering method to a part of lower magnetic film 11, 0.1 or a 0.2-micrometer nonmagnetic membrane is formed by the sputtering method on it, and it considers as the gap film 4. adding oxygen and nitrogen into Fe, CoFe, or a CoNiFe alloy at the magnetic film which satisfies this property, and adding oxygen, nitrogen, and an element with a strong affinity simultaneously, or aluminum2 -- O3 and SiO2 etc. -- by carrying out the laminating of the ferromagnetic to an oxide or a nitride, a high specific resistance film is realizable Moreover, a magnetostriction constant can be controlled by other alloying elements (for example, 3d transition metals) or adjustment of hardener composition, and it depends for it also on oxygen or nitrogen concentration by it. The ground 3 of a plating film is formed by the sputtering method on this high specific resistance film. A ground 3 can also be considered as a high specific resistance film by considering as the material mentioned above, and thickness is 100nm or less. The resist frame 2 is formed on a ground 3, and the up magnetic film 1 is produced by the galvanizing method. the width of recording track -- the interval of a frame -- being decided -- the frame galvanizing method -- 0.5 micrometers up to -- it was checking that it was producible without composition change, and the width of recording track created 0.5 or the 1.5-micrometer head a resist frame -- the RIE (reactive ion etching) method -- SiO2 etc. -- an oxide is used as a mask and produced By the frame galvanizing method, specific resistance is the alloy film which makes a principal component Fe of 60 or less microomegacm, NiFe, CoFe, or CoNiFe. It is good also as structure which uses as a high specific resistance film a part of up magnetic film created by this galvanizing method, and is shown in drawing 5 . It is possible to reduce a side fringe by milling or the RIE method by using the up magnetic film 1 as a mask by removing a part of ground 3, gap film 4, and lower magnetic film 11 (up shield film of MR or GMR) without the reattachment (trimming). When using the RIE method, by optimizing a type of gas, gas pressure, and an etch rate, the up magnetic film 1 can be used as a mask, and it can etch into a perpendicular mostly. The thickness of a high specific resistance film is 0.5 of the thickness of a gap film. Or it is considering as 3 or more times, and the record performance degradation in high frequency can be suppressed. the thickness of the up magnetic film 1 -- 2 or 3 micrometers -- it is -- the up magnetic film 1 -- it is difficult to use all as the plating film of high specific resistance Its membrane stress is large, and in order that the film with which the reason is satisfied [with a plating film] of all properties (Quantity rho, low Hk, low [lambda]) may use the various additives for high resistance, and the additive for stabilization of a plating bath, when it adds, they are that management of a plating bath is difficult, that Bs falls, and that adjustment of a magnetostriction is more difficult than the sputtering method. Then, the

recording head of the structure which shows a part of up magnetic film in drawing 5 created by the high specific resistance up magnetic film 12 is producible.
[0072] As shown in drawing 3 , it is possible to produce the film (the lower magnetic film 5 and up magnetic film 1) of the upper and lower sides of a gap 4 by the galvanizing method, and to produce the high specific resistance up magnetic film 12 by the sputtering method on [frame] a part and the up magnetic film 1. In this case, gap films are conductive nonmagnetic membranes (Cr alloys, such as a CrNi alloy and a CrCu alloy, a NiW alloy, precious alloy, etc.). moreover, a frame -- SiO2 etc. -- it is an oxide, and like drawing 1 , there is no frame removal process and a frame remains in a surfacing side as it is The RIE method is used for frame formation. Or a frame is removed after plating film formation using a resist frame, and the lower magnetic film 5, the gap film 4, and the up magnetic film 1 of high Bs can be produced by the almost same width of face as a frame interval. Moreover, the height of a frame is good at the value near the sum total thickness of the up magnetic film 1, the lower magnetic film 5, and the gap film 4. The thickness of the up magnetic film 1 and the lower magnetic film 5 is about 3 or less times of the thickness of a gap film.
[0073] it is shown in drawing 2 as a recording head of drawing 3 and similar structure -- as -- up to a gap 4 and the ground film 3 -- the sputtering method -- after production and a frame -- SiO2 etc. -- it produces with an oxide, and the ferromagnetic of low specific resistance is formed in an up magnetic film by the galvanizing method, and the high specific resistance up magnetic film 12 is produced by the sputtering method on [frame] a part and the up magnetic film 1 still like drawing 3 Bs of a high specific resistance film is smaller than Bs of the up magnetic film 1 produced by the galvanizing method. Since it is a multilayer with ******, such as an oxide, or an oxide film in order to consider as high specific resistance, it becomes smaller than Bs of the up magnetic film 1. In this case, the lower magnetic film 5 may become larger than the method of others [fringe / side] a latus sake rather than the width of face (width of recording track) of the up magnetic film 1.
[0074] Although drawing 4 is drawing 1 and analogous structure, the thin high specific resistance up magnetic film 12 is formed with plating also on a gap 4. Thickness is 0.5 of a gap. Or it is 3 times, and plating is also possible, while the effect of high specific resistance will appear in a record performance clearly, if it is the thickness of this range. The high specific resistance up magnetic film 12 which consists of this plating film is a ferromagnetic alloy film containing elements, such as P, B, and O, and is specific resistance (60micro omegacm) smaller than the resistivity of the high specific resistance film currently formed by the above-mentioned sputtering method. Furthermore, it is also possible to use some up shield films 11 and a part of up magnetic film 12 as a high specific resistance (more than 80micro omegacm) film using the sputtering method, as shown in drawing 5 .
[0075] Drawing 5 is the structure of the recording head seen from the surfacing side, and the structure of a field where this head was perpendicularly cut from the surfacing side serves as drawing 6 (5). The lower magnetic pole and the up magnetic pole have multilayer structure, and the vertical magnetic films 13 and 14 in contact with the gap film 5 can be produced by the galvanizing method. The vertical magnetic films 13 and 14 are films which added 3d transition-metals element into a NiFe alloy, CoNiFe-(Pt, Pd) alloys, or these alloys. A gap film is producible using the same frame as a vertical magnetic film. For the magnetic properties of the vertical magnetic films 13 and 14, Bs is 1.0T. For specific resistance, 60 or less microomegacm and Hk are 20 above. A magnetostriction constant (lambda) is 1x10 to five or less below Oe. the thickness of the vertical magnetic films 13 and 14 -- each -- 3 or more times of a gap film -- it is -- the thickness of a gap film -- 0.1 micrometers it is . the material of a gap film -- a ratio -- it is a magnetic electric conduction film and they are a CrNi alloy, a CuCr alloy, a NiW alloy, or a noble-metals film The high specific resistance magnetic films 11 and 12 are producible by the sputtering method, and they are the mixed phase film of NiFe, the cascade screen of 2Oaluminum3 film and a NiFe film, and 2Oaluminum3 film, the mixed phase film of NiFeN and aluminum 2O3, or a multilayer of NiFeN and aluminum 2O3, and they control composition and film composition so that membranous specific resistance becomes high rather than the above-mentioned vertical magnetic films 13 and 14. In order to make specific resistance high and to use

the technique of multilayering or ****** as mentioned above, membranous saturation magnetic flux density falls and it becomes smaller than the vertical magnetic film produced by the galvanizing method. That is, the direction of the saturation magnetic flux density of the vertical magnetic films 13 and 14 in contact with the gap becomes higher than a high specific resistance film. It is better to carry out a high saturation-magnetic-flux-density film near the gap film like [in order to make high magnetic field strength on the gap of a surfacing side] this example. The thickness of the high specific resistance film 12 is about 3 micrometers. moreover, the width of face of the high specific resistance up magnetic film 12 and the high specific resistance lower magnetic film 11 -- the film of the vertical magnetic films 13 and 14 -- about 0.5 from -- 1 micrometer -- large -- the width of face of a vertical magnetic film -- about 0.5 micrometers it is . In plating, it is SiO2. What is necessary is to use a resist frame besides using a frame, to cover portions other than the vertical magnetic film 13 and 14 by protective coats (aluminum 2O3, SiO2, etc.) after resist removal after plating, and just to form the high specific resistance ferromagnetic of latus width of face on a vertical magnetic film and a protective coat. Although the coil serves as two-layer, one layer is sufficient at (5) of drawing 6 .

[0076] A vertical cutting plane is shown in drawing 6 from the sliding surface of a recording head. (1), (2), (3), (4), and (5) show the cutting plane corresponding to drawing 1 , drawing 2 , drawing 3 , drawing 4 , and drawing 5 , respectively. In (1), an up magnetic film consists of a magnetic film of one layer, a lower magnetic film consists of two-layer magnetic films, and the magnetic film near the gap film 56 of a lower magnetic film is a high specific resistance film. On the gap film 56, a coil 55 is in an insulator layer, and a magnetic field is generated from a surfacing side by passing current in a coil. One layer and the up magnetic film have [the lower magnetic film] two-layer structure, and the structure of (2) uses the magnetic film near the gap film 56 of an up magnetic film as the high saturation-magnetic-flux-density low specific resistance film 51. This high saturation-magnetic-flux-density low specific resistance film is produced with plating, and the width of face of this magnetic film determines the width of recording track. The width of face of the high saturation-magnetic-flux-density low specific resistance film which the high saturation-magnetic-flux-density low specific resistance film was formed only in the surfacing side side of an up magnetic film, and was seen from the surfacing side side is narrow as shown in drawing 2 rather than the high specific resistance magnetic film 52. The structure of (2) can form a ** truck easily rather than the structure of (1). (3) consists of magnetic films two-layer in a lower magnetic film and an up magnetic film. A lower magnetic film consists of a high saturation-magnetic-flux-density low specific resistance film 51 and a ferromagnetic 54 under it, and the up magnetic film consists of a high saturation-magnetic-flux-density low specific resistance film 51 and a high specific resistance magnetic film 52. The high saturation-magnetic-flux-density low specific resistance film 51 and the gap film 56 are produced by the galvanizing method, and produce the high specific resistance magnetic film 52 by the sputtering method. (3) And since the width of face which used the high saturation-magnetic-flux-density low specific resistance film for the upper and lower sides of the gap film 56, and was seen from the surfacing side with the structure of (5) can make it narrower than the width of face of other magnetic films, it is structure effective in the recording head of a ** truck, and magnetic field strength can be made high since the high saturation-magnetic-flux-density film is used near the gap and the magnetic film of high specific resistance is used, a RF property is also good. The high saturation-magnetic-flux-density film 51 forms (4) in the whole magnetic pole of the upper and lower sides of the gap film 56, and if only a surfacing side carries out ** truck processing like drawing 4 , it does not need to use the process which forms only a surfacing side side by the galvanizing method as shown in (3) and (5). (5) uses the high specific resistance magnetic film 52 for the magnetic pole material of the upper and lower sides which are separated from a gap using the high saturation-magnetic-flux-density low specific resistance film in contact with the gap film 56 although it had become (3) and similar structure, and a RF property is fitness and 1.0 micrometers. The following formation of a ** truck is possible. In drawing 6 , the high saturation-magnetic-flux-density low specific resistance film 51 is the material with saturation magnetic flux density smaller than the material of the high magnetic pole portion of others [specific resistance] from the magnetic pole material used for other portions in each recording head. The

material used for the high saturation-magnetic-flux-density low specific resistance film 51 is the material which added 3d transition-metals element into for example, a CoNiFe alloy, NiFe alloys, or these alloys. In producing with plating on the gap film 56, when producing a nonmagnetic electric conduction film by the other methods, the oxide of aluminum 2O3 or SiO2 grade or a nitride, carbide, or these mixed phases are sufficient.

[0077] The example of structure of the recording head of drawing 6 and similar structure is shown in drawing 7 . In (1), the magnetic film of the upper and lower sides which are separated from the gap film 56 in the high specific resistance magnetic film 52 is used, and the small ferromagnetic 54 of specific resistance is used for the magnetic-gap side rather than the high specific resistance magnetic film 52. The volume of the high specific resistance magnetic film 52 is larger than the volume of the ferromagnetic 54 of low specific resistance, and improves rather than the case where a RF property does not use a high specific resistance film. (2) A recording head with good ** truck and RF property can be offered by forming the magnetic film in contact with the gap film and the gap film by ** truck, and making the magnetic film on it into the high specific resistance magnetic film 52. The up magnetic film is three layers, (3) produces the gap film 56 to a flat part, and the high specific resistance magnetic film 52 is formed through a magnetic film with narrow width of face on it. It is possible by the ferromagnetic 54 of low specific resistance being on the high specific resistance magnetic film 52, and making high saturation magnetic flux density of this ferromagnetic 54 of low specific resistance to make magnetic field strength of a surfacing side high. saturation magnetic flux density of the material near the gap can be made higher than (3) because (3) makes the portion which is separated from a gap film to the ferromagnetic 54 of low specific resistance in the portion near the gap film 56 the high specific resistance magnetic film 52 although similar structure is the recording head of (4) and the up magnetic film has a three-tiered structure -- it can come out and magnetic field strength can offer a high head from (3)

[0078] Drawing 8 (a) shows the cross section of the magnetic head which has the new structure of this invention.

[0079] Between the lower core 25 and the up core 27, a coil 26 is **** rare ******. The coil 26 consists of aluminum with a thickness of 2 micrometers or Cu. It fills up with the insulating material 31 nonmagnetic for the purpose holding the electric insulation with a coil 26 and cores 25 and 27.

[0080] the magnetic head of this invention -- between the up core 27 and the lower cores 25 -- a magnetic pole -- the magnetic gap 10 which consists of an insulating nonmagnetic membrane is newly inserted with members 32 and 33, and the feature is in the point that a magnetic gap (or record gap) is formed of these members Moreover, the point of having formed the magnetic-path material 41 and 42 between the up core 27 and the lower core 25 is in other features. This structure is not indispensable structure when realizing this invention. The magnetic-path material 41 and 42 is suitable when realizing flattening of the up core 27, and it is effective in reducing the influence of the stress (magnetostriction) which remains after manufacture. said division material -- a magnetic pole -- the rise of a manufacturing cost was able to be prevented members 32 and 33, simultaneously by forming

[0081] This drawing (b) is drawing which looked at the magnetic head from the up core side. Signs that the coil 26 is rolled spirally are known. This coil 26 is combined with the electrode 30 (drawing (a)) by the contact hole 34. Moreover, the up core 27 and the lower core 25 are combined by the magnetic contact hole 35. This magnetic contact hole 35 has composition including the magnetic-path material 41 and 42 shown previously.

[0082] The insulating magnetic gap 10 which is the feature of this invention is located at the nose of cam of the up core 27 and the lower core 25, and has structure which a part exposes to a sliding surface. If the structure of said division material is seen from alpha, it will become as it is shown in drawing (c). namely, between the up core 27 and the lower cores 25 -- a magnetic pole with narrow width of face -- members 32 and 33 are inserted and the magnetic gap 10 which consists of an insulating nonmagnetic membrane exists in the position further inserted into these members a magnetic pole -- members 32 and 33 are magnetically [as the nose-of-cam magnetic pole of the up core 27 and the lower core 25] united, respectively For this reason, the

gap section will consist of magnetic poles which have a convex configuration mutually.
[0083] Moreover, drawing (c) understands signs that the above-mentioned magnetic head is in agreement with the magnetic pole structure seen from the record medium and the field to approach, and an up magnetic pole has a convex configuration from drawing, and heights are formed toward the lower magnetic pole.
[0084] Moreover, both these magnetic poles especially have a convex configuration, and drawing (c) shows that the width of face of the heights of an up magnetic pole and the heights of a lower magnetic pole is almost equal.
[0085] Moreover, in the case of this invention, it is about 0.8 micrometers about the height of heights. It carried out. Moreover, width of face of heights was set to 1 micrometer. The height of this relation to heights becomes low compared with the width of face of heights.
[0086] The structure indicated in this invention can lower magnetic-path resistance, and describes the principle using drawing 9 and drawing 10 . drawing 9 -- a magnetic pole -- the cross section of the conventional magnetic head of a publication is shown in JP,7-296328,A without members 32 and 33 Drawing 9 shows the magnetic gap inserted from the lower core 25 and the up core 27. The write-in magnetic flux to a medium 61 is drawn like the path indicated to be beta. However, in order to attain high-density record, when the width of face by the side of the gap nose of cam of the up core 27 (magnetic pole width of face) was narrowed, magnetic-path resistance increased and magnetic flux became remarkable [the phenomenon of flowing like Path alpha] from this influence in the field 50 which magnetic-path resistance increases. For this reason, the amount of magnetic flux led to the gap point 57 was not able to decrease, and required magnetic flux was not able to be taken out from a gap (magnetic pole) nose of cam.
[0087] on the other hand, the magnetic pole shown in drawing 10 -- the case of the magnetic head which has members 32 and 33 -- between the up core 27 and the lower cores 25 -- a magnetic pole -- members 32 and 33 exist For this reason, the path of Path alpha can be lengthened by the thickness of these members (the field of non-magnetic material can be made large). Even if magnetic-path resistance increases from this effect by narrowing magnetic pole width of face, the increase in the amount of magnetic flux which flows Path alpha can be pressed down low.
[0088] The above-mentioned effect was accepted also on the write-in frequency of 150MHz or more. This is the effect to which this invention used the insulating nonmagnetic membrane for the magnetic gap. Moreover, when amorphous magnetic films of high electric resistance, such as CoTaZr, were used for magnetic pole material, write-in frequency was able to be raised to 200MHz.
[0089] Conventionally which is indicated by JP,7-296328,A, with structure, since the inside of the trench structure used as heights consisted of low electric resistance material, it was easy to generate the eddy current in this portion, and the upper limit of write-in frequency was restricted to 100MHz.
[0090] moreover, it was shown in (c) of drawing 8 -- as -- a magnetic pole -- the width of face w1 of members 32 and 33 is narrow compared with the width of face of the up magnetic pole 27 and the lower magnetic pole 25 This is also the reason by which a magnetic pole configuration has a convex configuration. It cannot be overemphasized that magnetic flux concentrates on the heights which meet from the effect of this configuration. Therefore, coil current (write-in current) is adjusted and writing does not occur in any fields (a gap size becomes large) other than heights on the conditions which made in agreement the magnetic field from heights, and the magnetic field which is needed for the writing of a medium. Therefore, the width of face of the truck written in can be made mostly in agreement with the width of face of heights.
[0091] The field which is possible also for constituting only heights from high electric resistance and high saturation magnetization material, and is equivalent to the width of face of heights from this effect can be made to generate a strong magnetic field in this invention furthermore. Even if it has the magnetic pole configuration which has a convex configuration from this effect, it can perform restricting the write-in width of recording track to the width of face of heights efficient.
[0092] Moreover, if the process later described since it is low is used compared with the width of face of heights, width of face of heights will be made as for the height of heights to 2

micrometers or less. From this effect, width of face by which writing is performed to a medium is easily made to 2 micrometers or less.
[0093] There is no need that the width of face of the lower core 25 also dares narrow the width of face of the up core 27 when realizing high-density record, in order to determine by width of face of heights the width of face to which writing is performed furthermore in the case of this invention. There is no increase in the magnetic-path resistance from this effect, and a required magnetic field can be efficient and can lead to the magnetic pole nose-of-cam (gap section) section.
[0094] In the case of the conventional magnetic head which uses an insulating nonmagnetic membrane for a magnetic gap, a configuration will be divided roughly into three kinds shown in drawing 11 if a magnetic pole is seen from a sliding-surface side. What consists of magnetic poles 27 and 25 with the equal length indicated to be what consists of magnetic poles 27 and 25 from which the length which they show to (a) differs to (b), and the magnetic pole 25 which has a salient exist in one side further. (b) is what improved the magnetic pole structure of (a), and since the length of a magnetic pole is equal, it has the feature with few disclosure magnetic fields of the direction of the width of recording track. For this reason, it is thought that it is advantageous to the writing of a ** truck. However, with this structure, there is a fault which cannot use a magnetic pole 25 also [layer / shield / to a magnetoresistance-effect element]. It is the structure of (c) which coped with this fault.
[0095] In order to realize ** truck-ization in the structure of (c) shown in drawing 11 , it is necessary to narrow width of face W. For this reason, reduction of the write-in magnetic flux accompanying the increase in magnetic-path resistance shown in drawing 4 arises. For this reason, it is efficient and high-density information cannot be written in.
[0096] Since the width of face of the write-in gap section is restricted by the width of face of heights, the structure of this invention has few breadths of the disclosure magnetic field to the direction of the width of recording track like the magnetic pole shown in (b) of drawing 11 . For this reason, it is suitable for high-density record. Furthermore, since the width of face of a lower core is wider than the width of face of heights, any problem is not produced to use a lower core also [layer / shield / to a magnetoresistance-effect element], either.
[0097] The problem in connection with the high-density record which was described above and from which the magnetic-head structure of this invention became a problem by the magnetic head of the conventional technology like does not arise at all. The manufacturing process of the magnetic head which realizes this outstanding performance is described using drawing 12 .
[0098] This drawing looks at signs that the magnetic pole nose of cam of a magnetic core is formed from the direction "alpha" shown in drawing 8 (b). A process is described in order along drawing.
[0099] At the process (a), the laminating of the lower magnetic film 73 which constitutes a lower magnetic pole on a substrate (or a ground layer or ground structure) 74 was carried out first. The nickel-Fe alloy film was used as a magnetic film. Thickness was set to 2 micrometers. Besides, the laminating of the alumina film 75 with a thickness of 0.3 micrometers is carried out as an insulating nonmagnetic membrane, and it is 0.8 micrometers in thickness further. The laminating of the magnetic film 72 which consists of a nickel-Fe alloy was carried out. the resist pattern 71 of the width of face (it is equivalent to the write-in width of recording track) of heights after finishing a laminating -- a phot -- it formed by the lithography method Thickness was set to 1 micrometer.
[0100] Subsequently, at the process (b), the alloy magnetic film 72 was **********ed on the mask by the ion milling method in the resist pattern 71, and the portion used as the height of an up magnetic pole was formed. After an appropriate time, a part for the height of the up magnetic pole formed by the resist pattern 71 and etching was used as the mask, and the alumina film was **********ed by the reactant gas of a chlorine system and a fluorine system. Then, heights were formed in the lower magnetic pole by **********ing a lower magnetic pole on a mask by the ion milling method in the member used as a part for the heights of an up magnetic pole again. The etching depth in this case is 0.8 micrometers. It carried out. The height to which length was [magnetic pole / lower] equal to the mask by **********ing by the ion milling method in the

member used as a part for the heights of an up magnetic pole can be made to meet. This is effective when lessening the breadth to the direction of the width of recording track of a disclosure magnetic field, and it serves as an important element when operating this invention.
[0101] At the process (c), after carrying out the laminating of the nonmagnetic and insulating nonmagnetic membrane 76 to the whole surface, while carrying out flattening processing of nonmagnetic and the insulating film which carried out the laminating, a part of magnetic film 72 used as heights was exposed. After this process applies a heat-hardened type insulating material (called a spin-on glass) with the fluidity currently used for manufacture of a semiconductor etc., it performs predetermined heat treatment and can realize a substrate front face by carrying out wrapping processing mechanically further. Even if it uses the heat flow rate kinesis of a resist for others, it can form easily.
[0102] It is a requirement that the magnetic film 72 which serves as heights when realizing this invention is exposed from an insulating layer. If it is the process which can realize this, flattening processing of an insulating layer will be unnecessary, for example, it will dare check not causing any problem to this invention, either also in the state where the thickness of the magnetic film 72 from which the thickness of an insulating material 76 serves as heights is exceeded. Such when extreme (state which exceeds the thickness of the magnetic film 72 from which the thickness of an insulating material 76 serves as heights), a wave will arise in an up magnetic pole and a height will exist in the portion used as a valley. This structure is described independently.
[0103] The remaining members which finally constitute an up magnetic pole member from a process (d) were formed. As up magnetic pole material, the nickel-Fe alloy film was used like before.
[0104] According to the process described above, the magnetic pole structure shown in drawing 8 (c) can be formed. In this example, although the nickel-Fe alloy film was used as a magnetic pole material, even if it used other soft-magnetism films, the magnetic head of this invention was able to be formed from the same process as this example. The writing in a RF state was realizable by using the soft-magnetism film of high electric resistance especially. The point which does not depend on an electroplating method but can form this soft-magnetism film is the feature of this invention, and the RF writing of it in which the conventional magnetic head is exceeded from this effect is attained.
[0105] Next, the structure of having a valley is stated to an up magnetic pole. This structure can be manufactured from the manufacturing process of the magnetic head which includes the following process at least. It states like the point using drawing 12 .
[0106] First, as shown in (a), after carrying out the laminating of the lower magnetic pole material 73 on the magnetic-head ground structure 74, the laminating of the nonmagnetic membrane 75 which consists of an alumina was carried out, and the laminating of the magnetic film 72 used as the heights which constitute a part of up magnetic pole further was carried out.
[0107] Next, the resist pattern 71 was formed in the field which uses the lithography method and is equivalent to the heights of an up magnetic pole on the above-mentioned laminated structure.
[0108] Subsequently, heights were formed in the lower magnetic pole by **********ing an insulating nonmagnetic membrane and a lower magnetic pole on a mask in the member which becomes a part for the heights of the above-mentioned resist pattern 71 and an up magnetic pole as shown in (b).
[0109] Then, as shown in (c), after forming the member which serves as heights in the upper part and a lower magnetic pole, the laminating of nonmagnetic and the insulating film 76 was carried out by the thickness which exceeds heights to fields other than heights. Although it is displayed that the front face of the insulating nonmagnetic membrane 76 and the front face (72 front faces) of heights are located drawing in the same side, in this example, the thickness of the insulating nonmagnetic membrane 76 exceeds the front face (72 front faces) of heights.
[0110] The magnetic-head magnetic pole configuration made into the purpose by forming the up magnetic film 77 which is the remainder of up magnetic pole material as shown in (d) after an appropriate time was manufactured.
[0111] The magnetic pole configuration of the magnetic head manufactured from the process which includes the above-mentioned process in drawing 13 at least is shown. From drawing,

heights understand well the configuration of the up magnetic film 77 which has a valley.
[0112] This configuration specifies that it was efficient, when drawing the magnetic flux of an up magnetic film in a height efficient.
[0113] The magnetic head of this invention was formed on the wafer which machined the sintered compact of an alumina and a titanium carbide. Then, predetermined machining was performed and the magnetic-head slider was manufactured.
[0114] According to the above-mentioned process, the width of face of the height which specifies the write-in width of recording track is decided by width of face of a resist pattern. However, the height of the magnetic pole height of this invention is making it lower than the width of face of a height, and does not dare need the thick resist pattern of thickness. this effect -- since -- compared with the resist pattern used as the mask pattern for plating, resolving is easy and sets width of face of a height to 2 micrometers or less -- things can be carried out The magnetic head dealing with a ** truck can be easily manufactured from this feature.
[0115] By using the head slider which consisted of these magnetic heads, high-density record of 2 micrometers or less of width of recording track can be attained. 5Gb/inch2 considered to be conventionally impossible from this effect The above high-density magnetic recording medium is realizable. This is the effect which was able to draw magnetic flux efficient to a part for a magnetic pole point, and this effect was born by having constituted the magnetic pole nose of cam from a magnetic pole which has a salient mutually.
[0116] (Example 2) Drawing 14 uses a high specific resistance film given in an example 1 for a recording head, and shows an example of the record reproducing head which combined the reproducing head indicated to be a recording head below. The huge magnetoresistance-effect film 104 is used for the reproducing head, and the electrode 105 for passing current touches the huge magnetoresistance-effect film 104 electrically. Under an electrode 105 and the huge magnetoresistance-effect film 104, the lower shield film 106 is through a lower gap film. On the huge magnetoresistance-effect film 104, the high specific resistance lower magnetic film 108 which turns into an up shield film through an up gap film is, and the high specific resistance lower magnetic film 108 has become a part of lower magnetic pole of a recording head. It is possible to use a part of this high specific resistance lower magnetic film 108 as a high specific resistance film, and to improve the RF property of a recording head. The gap film 102 of a recording head has equal magnetic film and width of face of the upper and lower sides, and its material of high saturation magnetic flux density is [the up-and-down high saturation-magnetic-flux-density film 101,103] more desirable than other magnetic pole portions. The latus quantity specific resistance up magnetic film 107 of width of face is used on this high saturation-magnetic-flux-density film 101. Current is passed in the coil 109 of a recording head, and it is recorded on a record medium 110 by the magnetic field from a recording head. In addition, the head of different structure which used the ferromagnetic tunnel film is sufficient as the reproducing head.
[0117] Drawing 15 is the fragmentary sectional view of the magnetic head (MR sensor) using the spin bulb magnetoresistance-effect film of other structures of this invention.
[0118] MR sensor of this invention is the structure where the 1st magnetic layer 45 of an elasticity ferromagnetic, the non-magnetic metal layer 21, and the 2nd magnetic layer 22 of a ferromagnetic were made to adhere on a suitable substrate 43 like glass and a ceramic. When the magnetic field is not impressed, it is made for the ferromagnetic layers 45 and 22 to become the angle difference each magnetization direction of whose is about 90 degrees. Furthermore, the magnetization direction of the 2nd magnetic layer 22 is fixed in the same direction as the direction of a magnetic field of a magnetic medium. The magnetization direction of the 1st magnetic layer 45 of an elasticity ferromagnetic in case the magnetic field is not impressed leans 90 degrees to the direction of a magnetic field of the 2nd magnetic layer. It sympathizes with the impressed magnetic field, and magnetization rotation arises and changes to the 1st magnetic layer 45.
[0119] The 1st magnetic layer 45 in this example, the non-magnetic metal layer 21, the 2nd magnetic layer 22, and the antiferromagnetic substance layer 23 can use the film composition used by the laminated structure shown in below-mentioned drawing 16 , drawing 17 , and drawing

18 , and can use Co82Cr9Pt9 and Co80Cr8Pt9(ZrO2) 3 for the hard ferromagnetism layer 47. The film composition of these drawing 16 , drawing 17 , and drawing 18 has the film composition equivalent to the 1st magnetic layer 45 and the 2nd magnetic layer 22 in this example, and those directions of a magnetic field are formed like the above-mentioned.

[0120] Before adhering the 1st magnetic layer 45 of an elasticity ferromagnetic, a suitable lower film 24 like Ta, Ru, or CrV is made to adhere on a substrate 43 in this example. The purpose to which the lower film 24 is made to adhere is for making the organization of a layer which makes it adhere behind, a grain size number, and a form optimize. The form of a layer is very important for acquiring the big MR effect. That is because the very thin spacer layer of the non-magnetic metal layer 21 can be used according to the form of a layer. In order to make influence by diverging into the minimum furthermore, a lower layer has good high electric resistance. A lower layer can be used also as reverse structure, as mentioned above. A substrate 43 is sufficient high electric resistance, it is fully a flat surface and, in the case of the suitable crystal structure, the lower film 24 is unnecessary.

[0121] A means to produce bias is used for lengthwise [for making the 1st magnetic layer 45 hold in the domain state single in a direction parallel to space]. The hard ferromagnetism layer 47 in which a means to make lengthwise produce bias has high coercivity, high squareness, and high electric resistance is used. The hard ferromagnetism layer 47 touches the field of the edge of the 1st magnetic layer 45 of an elasticity ferromagnetic. The magnetization direction of the hard ferromagnetism layer 47 is parallel to space.

[0122] An antiferromagnetism layer can be contacted to the field of the edge of the 1st magnetic layer 45, and can be made to adhere, and bias lengthwise [required] is produced. As for these antiferromagnetism layers, what has fully different blocking temperature is better than the antiferromagnetism layer 23 used in order to make the magnetization direction of the 2nd magnetic layer 22 of a ferromagnetic fix.

[0123] Next, it is desirable that a capping layer of the material of high resistance like Ta is made to adhere to the whole MR sensor upper part for example. It has an electrode 28 and a circuit is formed between MR sensor structure, a current source, and a detection means.

[0124] Drawing 16 - drawing 18 are the films which constitute the magnetoresistance-effect element of this invention which replaced with each film of the non-magnetic metal layer 21 of drawing 15 , the 2nd magnetic layer 22, and the antiferromagnetic substance layer 23, and was formed, and were produced as follows by the RF magnetron sputtering system. In 3mm the atmosphere of a toll of argons, to the ceramic substrate with 1mm [in thickness], and a diameter of 3 inches, the laminating of the following material was carried out one by one, and they was produced. Each target of a tantalum, a nickel-20at% iron alloy, copper, cobalt, and chromium-50at% manganese was used as a sputtering target. By production of a chromium-manganese alloy film, the chip of the 1cm angle of an alloying element has been arranged on a chromium-manganese target, and composition was adjusted by increasing or decreasing the number of chips. Moreover, when making a Co-Fe-nickel layer as a ferromagnetic, on the cobalt target, the chip of the 1cm angle of nickel and iron has been arranged, and composition was adjusted.

[0125] The cascade screen impressed RF power to the cathode which has arranged each target respectively, it generated plasma, opened and closed every one shutter arranged for every cathode, and formed each class one by one in equipment. While impressing the magnetic field of about 30 Oe(s) in parallel with a substrate using a permanent magnet at the time of film formation and giving a uniaxial anisotropy, an example of the formation conditions of a layer which guided the direction of the switched connection magnetic field of a chromium-manganese film in the direction of an impression magnetic field is shown in Table 1.

[0126]

[Table 1]

表 1
積層膜形成条件例

層	Arガス圧力	rf出力	形成速度
Ta：	0.8mTorr	300W	0.25nm/s
NiFe：	3mTorr	350W	0.17nm/s
Cu：	3mTorr	150W	0.2nm/s
CrMnPt：	8mTorr	350W	0.5nm/s
Co：	3mTorr	250W	0.13nm/s

[0127] The cascade screen heat-treated in vacuum-heat-treatment equipment after formation. From a room temperature to predetermined temperature, for example, 250 degrees C, the temperature up of the heat treatment was carried out, and predetermined time, it was held for 1 hour, for example, and was performed by cooling to a room temperature. In the stroke of the above-mentioned temperature up, maintenance, and cooling, it carried out by impressing 5K of magnetic fields of Oe from 2 in parallel in the field of a substrate. The direction of the above-mentioned magnetic field was made into the direction parallel to the magnetic field impressed with the permanent magnet at the time of film formation.
[0128] Patterning of the formation of the element on a base was carried out according to the photoresist process. Then, the base was processed into the slider and carried in the magnetic recording medium.
[0129] Drawing 16 is drawing which compared the property heat treatment-spin bulb film which has magnetic layered product which used antiferromagnetism film / 81at%nickel-19at%Fe film of 45at% chromium-45at% manganese-10at% platinum before, and after heat treatment. The joint magnetic field by the 1 direction anisotropy appears as a shift amount of the loop of the right-hand side in drawing. The joint magnetic fields before heat treatment are 380Oe(s) also after 300Oe(s), 250 degrees C, and heat treatment of 3 hours. This is a size of the same grade as being shown by the well-known example, when NiFe layer thickness and the size of magnetization are taken into consideration.
[0130] Drawing 17 is drawing which compared the property heat treatment-spin bulb film which has magnetic layered product which used antiferromagnetism film / Co film of 45at% chromium-45at% manganese-10at% platinum before, and after heat treatment. Although the joint magnetic fields before heat treatment are 300Oe(s) and are the same as the case of drawing 1 almost, after 250 degrees C and heat treatment of 3 hours, the joint magnetic field is large to 600Oe(s) and a double-precision grade. This is a size about [of the joint magnetic field shown by drawing 1] double precision, when Co layer thickness and the size of magnetization are taken into consideration.
[0131] Drawing 18 is another example of composition at the time of using the magnetic layered product of this invention as a spin bulb magnetoresistance-effect film. The antiferromagnetism film 30 (45at%Cr-45at%Mn-10at%Pt) and the ferromagnetic layer 65 to stick The Co layer 111 directly joined to the antiferromagnetism film 30, the soft-magnetism layer 112 (81at%nickel-19at%Fe) with good magnetic properties, and a non-magnetic layer 62 (Cu) are touched directly, and it consists of a Co layer 113 which produces the huge magnetoresistance effect. The ground layer and the soft-magnetism layer 63 (81at%nickel-19at%Fe) by which the ground film 64 controls other membranous orientation and diameters of crystal grain are a free layer. That is, the thickness and the property of the ferromagnetic layer 65 can be maintained, without arranging Co layer to a joint with an antiferromagnetism film, and a joint with a nonmagnetic membrane, not degrading the magnetic properties of the ferromagnetic layer 65 which is the fixed bed, and increasing the amount of magnetization of the whole layer not much. Therefore, the soft-magnetism layer 112 has good magnetic properties, and it is desirable that it is smaller than the layers 113 and 111 which saturation magnetic flux density becomes from Co, for example, it is nickel81Fe19 film whose saturation magnetic flux density is one tesla. Or saturation magnetic flux density is reduced further and it is 0.5. A tesla grade is sufficient, for example, a NiFe-Cr film etc. is suitable, this NiFe-Cr film consists of a NiFe alloy containing 0-

20at%Cr, and a NiFe alloy consists of 75-95at%nickel and the remainder Fe.
[0132] (Example 3) Drawing 19 is the general drawing of a magnetic disk unit using the record reproduction discrete-type head shown in the example 2. The position on a record medium 203 is controlled by the head positioning mechanism 202 on the magnetic disk whose record reproduction discrete-type magnetic head 201 is the record medium 203 which rotates by the motor, and the record reproduction discrete-type magnetic head 201 is connected with the regenerative-signal processor 204.
[0133] It consists of an air filter for keeping pure the magnetic head for writing in, reading and carrying out the DC motor turning around a magnetic disk, and information and the pointing device of a means to change a position to a magnetic disk in support of this, i.e., an actuator and a voice coil motor, and the interior of equipment etc. in this equipment. An actuator consists of carriage, a rail, and bearing and a voice coil motor consists of a voice coil and a magnet. The magnetic disk of eight sheets is attached in the same axis of rotation, and these drawings show the example which enlarged total storage capacity.
[0134] A magnetic disk is surface roughness RMAX. It considers as 100A or less and the desirable good medium of front-face nature 50A or less. The magnetic disk has formed the magnetic-recording layer in the front face of a rigid base by the vacuum forming-membranes method. As for a magnetic-recording layer, a magnetic thin film is used. The thickness of the magnetic-recording layer formed by the vacuum forming-membranes method is 0.5 micrometers. Since it is the following, the front-face nature of a rigid base is reflected as front-face nature of a record layer as it is. Therefore, a rigid base is surface roughness RMAX. A thing 100A or less is used. As such a rigid base, the rigid base which makes a principal component glass, the soda alumino silica glass by which the chemical strengthening was carried out, or a ceramic is suitable.

[0135] Moreover, it is desirable in the case of a metal, an alloy, etc., for a magnetic layer to prepare an oxide layer and a nitride layer in a front face, or to use a front face as an oxide film. Moreover, use of a carbon protective coat etc. is desirable. By carrying out like this, the endurance of a magnetic-recording layer improves and damage on a magnetic disk can be prevented at the case where record reproduction is carried out by the ****** flying height, and the time of contact, a start, and a stop.
[0136] As a result of measuring the performance (over-writing property) of the recording head by this invention evaluated by such composition, the outstanding record performance of about -50dB was obtained also in the RF field 40MHz or more.
[0137] According to this example, it can fully record also in a RF field also to a high coercive-force medium, and they are the media transfer rate of 15MB/second or more, the record frequency of 45MHz or more, and magnetic-disk 4000rpm. It is 2 3 Gb(s)/inch as field recording density since MR sensor of the high sensitivity which has the MR effect which was excellent fast transmission of the above data, shortening of the access time, increase of storage capacity, and on the basis of the anisotropy magnetoresistance effect is obtained. The above magnetic disk unit is obtained.
[0138]
[Effect of the Invention] According to this invention, a part of magnetic pole of a recording head is created by the high specific resistance film, and since a record performance can make it hard to fall in high frequency, the magnetic storage of quantity recording density is obtained.
[0139] Furthermore, the high-density magnetic storage of the reproducing head which can offer a magnetic layered product with sufficient joint magnetic field and high temperature stability according to this invention, as a result has sufficient reproduction output and low noise figure, and high-reliability can be obtained.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Explanatory drawing seen from the surfacing side of the recording head which used the high specific resistance film for a part of lower magnetic film.
[Drawing 2] Explanatory drawing seen from the surfacing side of the recording head which used the high specific resistance film for a part of up magnetic film.
[Drawing 3] Explanatory drawing seen from the surfacing side of the recording head which used the high specific resistance film for a part of up magnetic film.
[Drawing 4] Explanatory drawing seen from the surfacing side of the recording head which used the high specific resistance film for the lower part and a part of up magnetic film.
[Drawing 5] Explanatory drawing seen from the surfacing side of the recording head which used the high specific resistance film for the lower part and a part of up magnetic film.
[Drawing 6] A head cross section perpendicular to the surfacing side of the recording head which used the high specific resistance film and the high saturation-magnetic-flux-density film for a part of magnetic pole.
[Drawing 7] A head cross section perpendicular to the surfacing side of the recording head which used the high specific resistance film for a part of magnetic pole.
[Drawing 8] The conceptual diagram showing the magnetic head of this invention.
[Drawing 9] Explanatory drawing in which the problem in the conventional magnetic head is shown.
[Drawing 10] Book
[Drawing 11] The magnetic pole configuration seen from the sliding-surface side of the conventional magnetic head.
[Drawing 12] Production process drawing of the principal part of the magnetic head of this invention.
[Drawing 13] Production process drawing of the principal part of the magnetic head of this invention.
[Drawing 14] The record reproducing head which used the high specific resistance film or high saturation-magnetic-flux-density film of this invention for a part of magnetic pole.
[Drawing 15] The perspective diagram of the magnetoresistance-effect element magnetic force sencor of the spin bulb type magnetic head concerning this invention.
[Drawing 16] The block diagram of the spin bulb film using the chromium-manganese alloy film / NiFe concerning this invention.
[Drawing 17] The block diagram of the spin bulb film using the chromium-manganese alloy film concerning this invention / Co.
[Drawing 18] A block diagram with the spin bulb magnetoresistance-effect film concerning this invention.
[Drawing 19] The magnetic disk unit using the record reproducing head of this invention.
[Description of Notations]
1 [-- 4 A plating ground film 56,102 / -- Gap film,] -- An up magnetic film, 2 -- A frame, 3 5 [A frame, 10 -- A magnetic gap, 11 -- Quantity specific resistance lower magnetic film,] -- A lower magnetic film, 6 -- SiO2 12 [-- The 2nd magnetic layer of a ferromagnetic,] -- A

quantity specific resistance up magnetic film, 21 -- A non-magnetic metal layer, 22 23 [-- An up core or an up magnetic pole,] -- An antiferromagnetism layer, 25 -- A lower core or a lower magnetic pole, 27 28 [-- A hard ferromagnetism layer, 51 / -- Quantity saturation-magnetic-flux-density low specific resistance film,] -- 32 An electrode, 33 -- A magnetic pole member, 47 52 [-- A ferromagnetic, 55 / -- Coil,] -- A quantity specific resistance magnetic film, 53 -- A quantity specific resistance magnetic film, 54 61,110,203 [-- Soft-magnetism layer,] -- A record medium, 62 -- A non-magnetic layer, 63 64 [-- A resist pattern, 72 / -- Magnetic film,] -- A ground film, 65 -- A ferromagnetic layer, 71 73 [-- An up magnetic film, 101 / -- Quantity saturation-magnetic-flux-density film,] -- 75 A lower magnetic film, 76 -- A nonmagnetic membrane, 77 103 [-- Electrode,] -- A quantity saturation-magnetic-flux-density film, 104 -- A huge magnetoresistance-effect film, 105 106 [-- A quantity specific resistance (lower part) magnetic film, 109 / -- A coil, 201 / -- The record reproduction discrete-type magnetic head, 202 / -- A head positioning mechanism, 204 / -- Regenerative-signal processor.] -- A lower shield film, 107 -- A quantity specific resistance up magnetic film, 108

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（A）　(11)特許出願公開番号

特開平10－241125

(43)公開日　平成10年(1998)９月11日

(51)Int.Cl.[6]	識別記号	ＦＩ		
Ｇ１１Ｂ　5/39		Ｇ１１Ｂ　5/39		
5/31		5/31		C
				K
				D

審査請求　未請求　請求項の数10　ＯＬ　（全 19 頁）

(21)出願番号　特願平9－342521

(22)出願日　平成９年(1997)12月12日

(31)優先権主張番号　特願平8－344941
(32)優先日　平８(1996)12月25日
(33)優先権主張国　日本（ＪＰ）
(31)優先権主張番号　特願平8－344995
(32)優先日　平８(1996)12月25日
(33)優先権主張国　日本（ＪＰ）

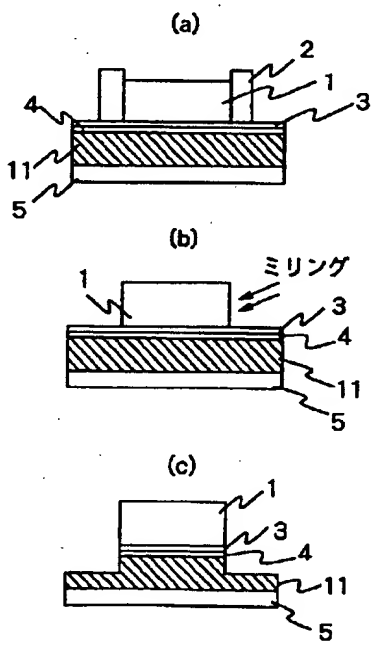
(71)出願人　000005108
株式会社日立製作所
東京都千代田区神田駿河台四丁目６番地
(72)発明者　小室　又洋
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72)発明者　星野　勝美
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72)発明者　芳田　伸雄
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(74)代理人　弁理士　小川　勝男

最終頁に続く

(54)【発明の名称】　薄膜磁気ヘッド及び記録再生分離型磁気ヘッドとそれを用いた磁気記憶再生装置

(57)【要約】
【課題】本発明の目的は、高周波記録における記録性能の低下を防止し、２μm以下の磁極幅を有する薄膜磁気ヘッドと記録再生分離型磁気ヘッド及び１０Ｇｂ／in^{2}級の超高密度磁気記憶装置を提供する。
【解決手段】下部磁性膜が再生部のシールド膜を兼ね、非磁性のギャップ膜が上部磁性膜と下部磁性膜の間に形成され、下部磁性膜あるいは上部磁性膜の一部が他の部分よりも８０μΩcm以上の高比抵抗を有し、また、フレームめっきによって上部磁性膜を形成し、上下部磁性膜のギャップ部を凸状にした記録ヘッドを用いる。

図　1



1…UP　2…フレーム　3…めっき下地
4…ギャップ　5…USL　11…USL（高比抵抗）

1

【特許請求の範囲】

【請求項１】非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備えた薄膜磁気ヘッドにおいて、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いことを特徴とする薄膜磁気ヘッド。

【請求項２】非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備えた薄膜磁気ヘッドにおいて、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いことを特徴とする薄膜磁気ヘッド。

【請求項３】請求項１又は２に記載の比抵抗の高い方の前記磁性膜は飽和磁束密度が他の磁性膜よりも小さいことを特徴とする薄膜磁気ヘッド。

【請求項４】非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備えた薄膜磁気ヘッドにおいて、前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上の比抵抗を有することを特徴とする薄膜磁気ヘッド。

【請求項５】情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを磁気シールドを設けられた記録再生分離型磁気ヘッドにおいて、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いことを特徴とする記録再生分離型磁気ヘッド。

【請求項６】情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを磁気シールドを介して設けられた記録再生分離型磁気ヘッドにおいて、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いことを特徴とする記録再生分離型磁気ヘッド。

【請求項７】情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを磁気シールドを介して設けられた記録再生分離型薄膜磁気ヘッドにおいて、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上の比抵抗を有することを特徴とする記録再生分離型磁気ヘッド。

2

【請求項８】情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを磁気シールドを介して設けられた記録再生分離型磁気ヘッドにおいて、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いこと、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いこと、及び前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上の比抵抗を有することのいずれかよりなり、前記再生ヘッドは、強磁性体と、該強磁性体に密着し、前記強磁性体に一方向異方性を発現させる反強磁性体とを含み、前記反強磁性体の少なくとも一部がＣｒ－Ｍｎ合金からなり、前記強磁性体の前記反強磁性体に密着する部分の少なくとも一部がＣｏもしくはＣｏ合金からなることを特徴とする記録再生分離型磁気ヘッド。

【請求項９】情報を記録する薄膜磁気ディスクと、該薄膜磁気ディスクの回転手段と、浮動型スライダに設けられ情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを有する記録再生分離型磁気ヘッドと、前記浮動型スライダを支持し薄膜磁気ディスクに対してアクセスする移動手段とを具備し、前記磁気ディスクが記録・再生時に４０００rpm 以上で回転し、記録周波数が４５ＭＨｚ以上である磁気記憶装置において、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いこと、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いこと、及び前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上の比抵抗を有することのいずれかよりなることを特徴とする磁気記録装置。

【請求項１０】情報を記録する薄膜磁気ディスクと、該薄膜磁気ディスクの回転手段と、浮動型スライダに設けられ情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを有する記録再生分離型磁気ヘッドと、前記浮動型スライダを支持し薄膜磁気ディスクに対してアクセスする移動手段とを具備し、前記磁気ディスクが記録・再生時に４０００rpm 以上で回転し、記録周波数が

3

４５ＭＨｚ以上である磁気記憶装置において、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いこと、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いこと、及び前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩｃｍ以上の比抵抗を有することのいずれかよりなり、前記再生ヘッドは、強磁性体と、該強磁性体に密着し、前記強磁性体に一方向異方性を発現させる反強磁性体とを含み、前記反強磁性体の少なくとも一部がＣｒ－Ｍｎ合金からなり、前記強磁性体の前記反強磁性体に密着する部分の少なくとも一部がＣｏもしくはＣｏ合金からなるを特徴とする磁気記憶再生装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、電子計算機及び情報処理装置等に用いられる磁気記録装置に係り、特に高密度記録を実現する上で好適な新規な薄膜磁気ヘッドと記録再生分離型磁気ヘッド及び磁気記憶再生装置に関する。

【０００２】

【従来の技術】情報機器の記憶（記録）装置には、主に半導体メモリと磁性体メモリが用いられる。アクセス時間の観点から内部記憶装置に半導体メモリが用いられ、大容量かつ不揮発性の観点から外部記録装置に磁性体メモリが用いられる。今日、磁性体メモリの主流は、磁気ディスクと磁気テープにある。これらに用いられている記録媒体は、Ａｌ基板ないしは樹脂製のテープ上に磁性薄膜が成膜されている。この記録媒体に磁気情報を書き込むため、電磁変換作用を有する機能部が用いられる。また、磁気情報を再生するため、磁気抵抗現象ないしは、巨大磁気抵抗現象あるいは電磁誘導現象を利用した機能部が用いられる。これら機能部は、磁気ヘッドと呼ばれる入出力用部品に設けられている。

【０００３】磁気ヘッドと媒体は、相対的に移動し、媒体上の任意の位置に磁気情報を書き込み、必要により磁気情報を電気的に再生する機能を有する。磁気ディスク装置を例に述べると、磁気ヘッドは、磁気情報を書き込み部と読み出しを行う再生部から構成される。書き込み部は、コイルとこれを上下に包みかつ磁気的に結合された磁極から構成される。再生部は、磁気抵抗効果素子部と同素子部に定電流を流し、かつ抵抗変化を検出するための電極から構成される。これら書き込み部と再生部の間には、磁気的なシールド層が設けられている。また、

4

これらの機能部は、磁気ヘッド本体上に下地層を介して形成されている。

【０００４】記録には電磁変換作用、再生に磁気抵抗効果が利用され、書き込み部に設けたコイルに誘導される電磁誘導電流を検出することによっても磁気情報の再生は可能である。この場合、記録と再生は１つの機能部で行うことができる。

【０００５】記憶装置の性能は、入出力動作時のスピードと記憶容量によって決まり、製品競争力を高めるためにはアクセス時間の短縮化と大容量化が必須である。また、近年、情報機器の軽薄短小化の要求から記憶装置の小型化が重要になってきた。これらの要求を満足するためには、単一の記録媒体内に多くの磁気情報を書き込み、かつ、再生できる磁気記憶装置の開発が必要である。

【０００６】この要求を満足させるためには、装置の記録密度を高める必要がある。高密度記録を実現するためには、書き込む磁区の大きさを微細化していく必要がある。これには、書き込み磁極の幅を狭くし、かつコイルに流す書き込み電流の周波数を高めることにより実現できる。

【０００７】

【発明が解決しようとする課題】高記録密度を実現するためには再生ヘッドは分解能が高く、記録ヘッドでは磁極端における磁束漏れを最小にするために、前述のようにギャップ長やトラック幅を狭くする必要がある。ギャップ長やトラック幅を狭くしていくと、磁極端間の磁束強度が減少する。ＭＲやＧＭＲ膜を再生部に設けた複合ヘッドでは再生部と記録部を組み合わせて作製，応用する。再生部のシールド膜と記録部の下部磁性膜は兼用されている。これにより製造プロセスが簡略化され、同一のサスペンション上で位置合わせ可能である。狭トラック記録ヘッドで問題となるのがサイドフリンジ及び高周波特性であり、最小トラック幅は、前者のサイドフリンジ磁界によって決定ずけられる。サイドフリンジ磁界の問題は下部磁性膜を切欠き、ペデスタル磁極端を形成することによりある程度防止できる。すなわち、特開平7－262519 号明細書ではサイドフリンジを低減するために、磁極端部にペデスタルを有している。またペデスタル磁極端層には高飽和磁気モーメントの材料、第２シールド層をパーマロイなどの低飽和モーメントの材料と説明している。この記述は下部磁性膜を高飽和／低飽和磁気モーメントの２層から形成することを示している。しかし、磁性膜の比抵抗については全く記載されていない。従って、高周波数記録を考慮すると、上記発明では満足できず、比抵抗や飽和磁束密度が重要な要件となる。

【０００８】また、上記従来技術によれば、磁極幅を２．５μｍ まで狭くし、周波数を９０ＭＨｚ程度まで高めることにより、２Ｇｂ／ｉｎ^{2}級の記憶密度を実現す

5

ることできる。しかしながら、さらなる高密度化を推し進めると下記に述べる問題が生じ、高密度化に限界が生じることが明らかとなった。

【０００９】この問題は、磁極幅を狭めるための製造技術に絡む問題と、磁極幅を狭めたことにより生じる磁気的な問題に大別できる。まず、製造技術に絡む問題を述べる。磁気的なギャップを構成する磁極は、記録媒体の磁化を反転させるために必要となる磁界を発生させる（漏洩させる）必要がある。この磁界は、記録媒体の保磁力と呼ばれる磁気的なパラメータによって決まり、近年の高密度記録用媒体ほど、強める必要がある。従って、強磁界を導くため、磁極部分の体積を減らすことはできない。すなわち、磁極幅を狭めても、磁極の厚みを薄くすることはできない。

【００１０】磁極材として一般に用いられている材料は、Ｎｉ－Ｆｅ合金である。この材料は、反応性のドライエッチングが困難である。このため、厚膜の磁極を形成することはできない。そこで、磁極の形成にはめっき法が用いられている。

【００１１】めっき法では、あらかじめ、磁極以外の領域をレジストパターンでマスクしておき、めっき用電極が露出する磁極部分のみに選択的にＮｉ－Ｆｅを成長させる。したがって、２μｍ以下の微細な磁極パターンを形成するためには、あらかじめ、２μｍ以下の幅でレジストパターンを形成しておく必要がある。

【００１２】ところでマスクパターンの厚みは、めっき時においてマスクとしての機能を維持するため、めっき高さ以上にする必要がある。これら、幅，高さの制約を受けるめっき用マスクパターンは、近接露光法にて形成されている。しかし、この方法での解像限界は、約２μｍ（厚みを約５μｍとしたとき）であり、これ以下のパターンを形成することはできない（Ｘ線リソグラフィ法等の高価な製造方法は考慮していない）。このため、従来法のままでは、高密度記録用の磁気ヘッドを製造することができない問題がある。

【００１３】更に、前述の磁気ヘッドの構造において、磁極幅を狭めるとギャップ近傍の磁路抵抗が増加することが良く知られている。この影響から、磁極幅を狭めるほど、磁束が上部磁性膜から下部磁性膜に流れてしまい、必要磁界がギャップ部から発生しなくなり、問題が生じる。

【００１４】また、高密度記録を実現するため、書き込み周波数を高めると書き込み効率が低下する問題が生じた。この問題は磁極部にうず電流が発生しやすく、この影響で磁路抵抗が増し、書き込み効率が低下することがわかった。

【００１５】うず電流が発生する原因として、第１は、磁気ギャップに金属膜しか適用出来ないこと、第２の理由は、うず電流の発生が少ない高抵抗膜やアモルファス膜等にて磁路を形成することが出来ないことである。う

6

ず電流の発生が少ない高抵抗膜やアモルファス膜等にて磁路を形成することが出来ない欠点に関しては、磁極をめっき法にて作製する従来の磁気ヘッドにも共通する問題である。

【００１６】本発明の目的は、高周波記録における記録性能の劣化を防ぐために、磁極端に部分的に高比抵抗の磁性膜を形成した薄膜磁気ヘッドと記録再生分離型磁気及び磁気記憶装置ヘッドを提供することにある。

【００１７】

【課題を解決するための手段】本発明は、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備えた薄膜磁気ヘッドにおいて、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いこと、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いこと、及び前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上、好ましくは８０μΩcm以上の比抵抗を有することのいずれかよりなることを特徴とする。

【００１８】本発明は、情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを磁気シールドを介して設けられた記録再生分離型磁気ヘッドにおいて、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いこと、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いこと、及び前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上の比抵抗を有することのいずれかよりなり、更に前記再生ヘッドは、強磁性体と、該強磁性体に密着し、前記強磁性体に一方向異方性を発現させる反強磁性体とを含み、前記反強磁性体の少なくとも一部がＣｒ－Ｍｎ合金からなり、前記強磁性体の前記反強磁性体に密着する部分の少なくとも一部がＣｏもしくはＣｏ合金からなることを特徴とする。

【００１９】本発明は、情報を記録する薄膜磁気ディスクと、該薄膜磁気ディスクの回転手段と、浮動型スライダに設けられ情報の書き込みを行う記録ヘッドと読み出しを行う再生ヘッドとを有する記録再生分離型磁気ヘッドと、前記浮動型スライダを支持し薄膜磁気ディスクに

7

対してアクセスする移動手段とを具備し、前記磁気ディスクが記録・再生時に４０００rpm 以上で回転し、記録周波数が４５MHz以上である磁気記憶装置において、前記記録ヘッドは、非磁性の磁気ギャップ膜を介して上部磁性膜と下部磁性膜とを備え、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、磁性膜の少なくとも１層の磁性膜の比抵抗が他の磁性膜の比抵抗よりも高いこと、前記上部磁性膜及び下部磁性膜の少なくとも前記磁気ギャップ部分が２層以上の磁性膜によって構成され、前記ギャップ膜から離れた第１の磁性膜の比抵抗が磁気ギャップ膜と接した第２の磁性膜の比抵抗よりも高いこと、及び前記下部磁性膜及び上部磁性膜の前記磁気ギャップ部分が凸形状を有し、前記上部磁性膜及び下部磁性膜の少なくとも一部が５０μΩcm以上の比抵抗を有することのいずれかよりなり、更にまた前記再生ヘッドは、強磁性体と、該強磁性体に密着し、前記強磁性体に一方向異方性を発現させる反強磁性体とを含み、前記反強磁性体の少なくとも一部がＣｒ－Ｍｎ合金からなり、前記強磁性体の前記反強磁性体に密着する部分の少なくとも一部がＣｏ又はＣｏ合金からなることを特徴とする。

【００２０】（記録ヘッド）本発明に係る記録ヘッドは、下部磁性膜がMRやGMR等の再生ヘッドとのシールド膜を兼ね、非磁性のギャップ膜が上部磁性膜と下部磁性膜の間に形成され、下部磁性膜あるいは上部磁性膜の一部をスパッタリング法や真空蒸着法などのドライプロセスで作成し、好ましくは８０μΩcm以上の比抵抗を有し、めっき膜のフレームをSiO_2で形成し、その幅が記録のトラック幅を決定し、トラック幅が１．５μｍ以下であることが好ましい。

【００２１】８０μΩcm以上の高比抵抗を有する磁性膜が飽和磁束密度１．５Ｔ 以上であり、ギャップ膜上下の磁性膜端部をＲＩＥにより加工し、ギャップ膜上下の磁性膜の幅をそろえることが好ましい。

【００２２】更に、８０μΩcm以上の高比抵抗を有する磁性膜の磁歪定数の絶対値が1×10^{-7}以下とするのが好ましく、上下磁性膜の一部の０．５μｍ 以上の膜厚を高比抵抗膜で形成することが好ましい。浮上面から見た磁性膜の幅が低比抵抗の磁性膜の一部よりも高比抵抗の磁性膜の一部の方が広いことが好ましい。

【００２３】面記録密度が増加すると共に、磁気ディスク装置の記録周波数も増加する傾向にある。記録周波数が１００MHzを超えると、磁性膜のうず電流損失が大きくなり、記録特性が劣化する。トラック幅２μｍ，ギャップ長０．３μｍ，磁性膜の飽和磁束密度を１．０Ｔとしたとき、１００MHz以上の高周波数条件の時の磁性膜の比抵抗は高い程磁界強度が高くなり、８０μΩcm以上が良い。この計算結果から、磁極の一部、特に端部の磁性膜には高比抵抗の膜を用いる必要があることがわかる。さらに、ライト後ノイズの低減及び記録ヘッド作

8

製時の磁性膜に付加する磁界中熱処理を低減させるために、磁性膜の磁歪定数を1×10^{-7}以下に小さくすることが望ましい。また磁性膜の飽和磁束密度は、磁性膜の膜厚を薄くし、更に、飽和を防ぐために、１．５Ｔ 以上の高いものとすることが望ましい。

【００２４】さらに浮上面が図３に示す構造の場合と、現在量産化しているヘッド構造を比較して評価すると、ギャップ膜４に接した磁性膜５及び磁性膜１のＢｓを高くし、ギャップ膜から離れた磁性膜５および磁性膜１２の比抵抗ρを高くすることが高磁界勾配及び高周波特性に寄与することが明らかになっている。上記の全ての磁性膜が高Ｂｓ，高ρ，低λ，低Ｈｋ、かつ単層膜で作製することが可能であれば、磁界強度が高く、良好な高周波特性をもった記録ヘッドが得られるが、このような特性の磁性膜を量産することは困難である。そこで、ギャップ付近の磁性膜は高Ｂｓ，低ρの材料を、ギャップから離れた磁極の一部あるいは全てを高ρの磁性材料にすることにより、量産可能な材料を用いて、良好な記録特性をもつ磁気ヘッドを提供できる。例えば、これらの特性を満足する高比抵抗、高飽和磁束密度を有する膜でかつ小さな磁歪定数（好ましくは絶対値が1×10^{-7}以下）を有する３ｄ遷移金属からなる膜をめっき法で厚く（３μｍ程度）作製することは困難である。しかし、スパッタリング法を用いれば、これらの特性を満足する磁性膜がＦｅ系，ＦｅＣｏ系あるいはＦｅＮｉＣｏ系に酸素や窒素を添加し、また他の合金元素を用いて磁歪定数を制御することが可能である。あるいはスパッタリング法を用いればＦｅ系，ＦｅＣｏ系あるいはＦｅＮｉＣｏ系の強磁性合金膜とAl_2O_3やSiO_2等の酸化物との多層又は混相膜にすることにより、うず電流を小さくすることが可能である。これらの磁性膜をスパッタリング法で作成した膜のみで構成し、更に狭トラック（好ましくは１．５μｍ 以下）に形成することはめっき法を適用した場合よりも困難であるため、ギャップ膜の上に作成する上部磁性膜(UP)の中の少なくともギャップ膜と接触する部分（ギャップ長の約３倍）はめっき法で作製する方法が有効である。

【００２５】記録ヘッドの性能の一つである磁界強度は、コアの中のギャップに最も近い部分をＢｓにする方が、ギャップから離れた部分を高Ｂｓにするよりも高くなる。特に、ギャップの浮上面側付近の磁性膜の磁気特性が性能に強く影響するため、浮上面側からギャップ膜と接触した部分（ギャップ付近）を高Ｂｓとし、高Ｂｓ膜以外の部分を高ρ（低Ｂｓでも良い）とする構造が狭トラック幅（１．５μｍ以下）の記録ヘッド構造として有効である。浮上面から見た場合、ギャップ膜と接する磁性膜の幅は、トラック幅の値に対応した幅に形成する必要がある。めっき法で磁性膜を形成する場合には、めっきフレームの間隔がめっき膜の幅すなわちトラック幅を決定でき、０．３～１．５μｍ 幅のめっき膜も形成可

9

能である。また、めっき法では、Ｆｅ，Ｎｉ，Ｃｏ及びこれらの２元あるいは３元合金膜を容易に形成でき、高Ｂｓ（1．5Ｔ以上）の膜（ＣｏＮｉＦｅ合金，ＮｉＦｅ合金）も形成できるため、トラック幅を決定するギャップ膜に接触（あるいはギャップ膜近傍）した磁気コアの一部にめっき膜を適用できる。このめっき膜の比抵抗は、上記強磁性元素のみから構成した場合には高々５０μΩcmであり、３ｄ遷移金属元素を添加しＢｓ１．３Ｔ以上の膜の場合のρは、約６０μΩcm、半金属元素を添加しＢｓ０．９Ｔ 以上のめっき膜の場合、ρは約１００μΩcmとなる。図３の１や５の磁性膜には、上記の説明のように高Ｂｓ膜が必要であり、１２や５の磁性膜のρが高い値であれば、磁性膜（１や５）のρは高くしなくても良い。すなわち、磁極材料の体積で、高ρ材料の方が、高Ｂｓ膜（低ρ）材料よりも体積に占める割合が多くなる。

【００２６】図１に示すように、下部磁性膜の一部１１にスパッタリング法で高比抵抗（８０μΩcm以上），高Ｂｓ＞1．５Ｔ，磁歪定数（絶対値で）として好ましくは1×10^{-7}以下の膜を作成し、その上に０．１ないし０．２μｍの非磁性膜をスパッタリング法で形成し、ギャップ膜４とする。その上にめっき膜の下地３をスパッタリング法により形成する。この下地３は高比抵抗膜とすることも可能である。下地３の上にレジストフレーム２を形成し、めっき法で上部磁性膜を作製する。トラック幅はフレームの間隔で決まり、フレームめっき法では０．５μｍ まで組成変動なく作製できることを確認している。さらに、上部磁性膜１をマスクとしてミリングやＲＩＥ（リアクティブエッチング）法等のドライエッチング法により、下地３やギャップ膜４及び下部磁性膜（ＭＲやＧＭＲの上部シールド膜）の一部を再付着なしで除去することにより、サイドフリンジを低減することが可能である。高比抵抗膜の膜厚は、ギャップ膜の膜厚の０．５ ないし３倍以上とすることで、高周波数における、磁界強度、即ち記録性能の低下を抑制できる。図１とは別に、ギャップ４の上下の膜（下部磁性膜５及び上部磁性膜１）をめっき法で作製し、下部磁性膜５や上部磁性膜１の幅よりも大きい幅で、かつ厚い膜で高比抵抗膜を作製することで記録性能を高めることができる。例えば、フレームの一部上と上部磁性膜１上に高比抵抗膜１２をスパッタリング法で作製することが可能である。この場合、ギャップ膜は導電性非磁性膜（Ｃｒ合金等）である。また、フレームはSiO_2等の酸化物であり、図１のようにフレーム除去工程はなく、フレームがそのまま浮上面に残る作製法がある。めっきフレームにはレジストを用いてもよい。図４は図１と類似の構造であるが、ギャップ４の上にもめっきで薄い高比抵抗，高Ｂｓ膜１２を形成している。膜厚はギャップの０．５ ないし３倍であり、この範囲の膜厚であれば、高比抵抗の効果が明瞭に記録性能に表れると共に、めっきも可能である。この高比抵抗めっき膜１２はＰ，Ｂ，Ｏ等の元素を含む強磁性合金膜である。

10

【００２７】これらのめっき法で高Ｂｓ，低Ｈｋ，高ρ，低λの膜を作製することは困難であるため、図５に示すようにスパッタリング法を用いて上部シールド膜の一部１１及び上部磁性膜の一部１２を高比抵抗（８０μΩcm以上）膜とすることも可能である。

【００２８】図５では、ギャップ膜上下の磁性膜１３及び磁性膜１４をめっき法で作製している。スパッタリング法等で作製する高比抵抗膜（シールド膜の一部１１及び上部磁性膜の一部）のＢｓよりも、上記磁性膜１３及び１４のＢｓの方が高い。ギャップ膜に近い磁性膜のＢｓを高くすることで、ギャップからの磁界強度が高くなり、スパッタリング法で作製した高ρ磁性膜（１１，１２）により、高周波特性が改善される。また図５に示すように、磁性膜１３，ギャップ膜１４及び磁性膜１４の幅（浮上面から見た時）は、ギャップ膜１４からさらに離れている磁性膜（１１及び１２）の幅より狭いことが特徴であり、このような構造にすることにより、記録ヘッドの磁界勾配を大きくすることができる。

【００２９】本発明における記録ヘッドは前述のようにギャップ部の磁性膜を互いに凸形状を有する対面磁極にて挟む構成したものである。

【００３０】また、上記磁気ヘッドが記録媒体と接近する面において露出する磁気コアの先端の磁極形状に関し、特に上部磁極が凸形状を有し、又、下部磁極に向かって凸部を形成すること、上部及び下部磁極を凸形状とし、かつ、凸部が互いに向き合う構成とすると共に、上部磁極の凸部の幅中心と下部磁極の凸部の幅中心がそれぞれ同一線上に重なるよう配置すること、上部及び下部磁極を凸形状とし、かつ、凸部が互いに向き合う構成とすると共に、凸部の高さを凸部の幅に比べ低くすることのいずれかとするのが好ましい。

【００３１】本発明に係る記録ヘッドを下記の工程によって製造するのが好ましい。

【００３２】（１）磁気ヘッド下地構造の上に下部磁極材を積層した後、絶縁性非磁性膜を積層し、さらに上部磁極の一部を構成する凸部となる材料を積層する工程。

【００３３】（２）上記積層構造の上にリソグラフィ法を用いて上部磁極の凸部に相当する領域にレジストパターンを形成する工程。

【００３４】（３）上記レジストパターン並びに上部磁極の凸部分となる部材をマスクに絶縁性非磁性膜並びに下部磁極をエッチングすることで下部磁極に凸部を形成する工程。

【００３５】（４）上部及び下部磁極にて凸部となる部材を形成した後、非磁性かつ絶縁性膜を全面に積層するか、又は凸部以外の領域に凸部を超える膜厚で積層する工程。

【００３６】（５）上部磁極部材を構成する残りの部材

11

を形成することで、凸部を谷とする上部磁極を形成する工程。

【００３７】（６）非磁性かつ絶縁性膜を平坦化処理すると共に、凸部となる部材の一部を平坦化面に露出させる工程。

【００３８】（７）上部磁極部材を構成する残りの部材を形成する工程。

【００３９】又は、

（再生ヘッド）本発明における再生ヘッドは前述の磁気抵抗効果型素子からなり、軟磁性膜と強磁性膜とは磁界方向が互いに９０度傾いていて、記録媒体からの磁界によって自由層となる磁性膜が固定層となる磁性膜に対して０～１８０度の磁界が変化し得るものである。

【００４０】本発明では高記録密度に対応する手段として、巨大磁気抵抗効果を用いた磁気抵抗効果素子を磁気ヘッドに搭載した磁気記録装置を用いる。

【００４１】その課題の一つとして、強磁性膜と直接積層して交換結合バイアスを生じる反強磁性膜の開発がある。課題を解決するための手段として、本発明では第一に、前記反強磁性膜の主成分をクロム及びマンガンとする。第二に、その特性を良好とするために白金族，金，銀，銅，ニッケル，コバルトの一つあるいはこれらの中から選択した複数の元素を加えてこの構造を体心立方構造のまま、格子定数を増加せしめて交換結合磁界の大きさと、温度特性を改善する。第三に強磁性体と反強磁性体の間に発生する一方向異方性の大きさを増大させるため、強磁性体の組成をコバルト、またはコバルトを主成分としたコバルト合金とする。コバルト合金の組成は、軟磁性体として用いる場合はＣｏ－Ｆｅ－Ｎｉ合金が良く、また高保磁力材料として用いる場合にはＣｏ－Ｐｔ合金が良い。第四に、一方向異方性の方向を揃えるために、熱処理を行う。第五に、特にスピンバルブ型磁気抵抗効果膜に有効であるが、反強磁性層に接する強磁性層を３層もしくはそれ以上の強磁性層の積層体とし、また、合計厚さを３ｎｍ以上にして磁気抵抗効果などの特性の熱劣化を防止する。

【００４２】本発明ではこのような材料構成、及び磁気特性を用いた磁気抵抗効果素子を再生部とした磁気記録再生装置において、高記録密度、すなわち記録媒体上に記録される記録波長が短く、また、記録トラックの幅が狭い記録を実現して、十分な再生出力を得、記録を良好に保つことができる。

【００４３】すなわち本発明に係る磁気抵抗効果素子は、固定バイアスあるいは縦バイアスをクロム基合金の反強磁性体あるいはＭｎ基合金の反強磁性体とコバルト系強磁性体で実現する。また、反強磁性膜に接する強磁性層を３層以上の強磁性層の積層体、例えば、Ｃｏ／ＮｉＦｅＣｒ／Ｃｏのように構成して、その合計厚さを３ｎｍ以上好ましくは３～２０ｎｍにすることで高い抵抗変化率，大きな交換結合磁界，高い熱安定性を有したスピンバルブ型磁気抵抗効果素子を実現し、この結果良好な感度と信頼性を兼ね備えた磁気抵抗効果素子，磁気ヘッドと、記録密度の高い磁気記録装置を得ることができる。

12

【００４４】本発明に係る再生ヘッドは、強磁性体と、強磁性体に密着する反強磁性体とを含む磁気センサであって、前記強磁性体に一方向異方性を発現させる前記反強磁性体の少なくとも一部がＣｒ－Ｍｎ合金であり、前記強磁性体の前記反強磁性体に密着する部分の少なくとも一部がＣｏもしくはＣｏ合金からなるものである。また、本発明に係る再生ヘッドは、非磁性金属層によって仕切られた強磁性体の第１及び第２磁性層と該磁性層のいずれかに接して設けられた反強磁性層とを有し、印加磁界がゼロである場合に前記強磁性体の第１磁性層の磁化方向が、前記第２層の磁化方向に対し直交する方向を有し、前記第２磁性層の磁化方向を固定する手段を有する場合と有しない場合とがあり、前記磁気抵抗効果素子に電流を生じさせる手段と、検知される磁界の関数として、前記第１層の磁化の回転によって生じる前記磁気抵抗センサの電気抵抗変化を検知する手段とを有し、前記第１及び第２磁性層がＣｏ又はＣｏ合金であり、前記反強磁性層がＣｒ－Ｍｎ合金であることを特徴とする。

【００４５】前記磁気抵抗効果素子は、軟磁性層／非磁性層／強磁性層／反強磁性層の構成を有し、外部の磁界に応じて前記軟磁性層の磁化が回転し、前記強磁性層の磁化との相対角度が変わって磁気抵抗効果作用を有することが好ましい。

【００４６】前記Ｃｒ－Ｍｎ合金は３０～７０原子％Ｍｎを含有するものが好ましく、更にＣｏ，Ｎｉ，Ｃｕ，Ａｇ，Ａｕ，Ｐｔ，Ｐｄ，Ｒｈ，Ｒｕ，Ｉｒ，Ｏｓ及びＲｅからなる群から選択された少なくとも一つを合計含有量で０．１～３０原子％含有することができる。

【００４７】前記強磁性層がＣｏもしくはＣｏ合金又はＮｉ合金薄膜を介して両面にＣｏ又はＣｏ合金薄膜を有する積層体からなり、前記反強磁性層がＣｒ－Ｍｎ合金又は、Ｃｒ－Ｍｎ－Ｘ合金であり、前記Ｘが、Ｃｏ，Ｎｉ，Ｃｕ，Ａｇ，Ａｕ，Ｐｔ，Ｐｄ，Ｒｈ，Ｒｕ，Ｉｒ，Ｏｓ及びＲｅからなる群から選択された少なくとも一つであって合計含有量が０．１～３０原子％であるのが好ましい。

【００４８】前記磁気記憶装置は、装置環境温度が１００℃以上で駆動すること、前記磁気センサが、前記強磁性層と反強磁性層との積層構成に発生する一方向異方性と、磁気センサに流れる電流から発生する磁界とが略同方向であること、前記一方向異方性が消失するブロッキング温度より低い温度で加熱し、磁界を印加しながら冷却する着磁工程を行うことが好ましい。

【００４９】本発明は以下の要件の少なくとも１つを有するものが好ましい。

【００５０】前記第二の強磁性層の飽和磁束密度が前記

第一および第二の強磁性層の飽和磁束密度より小さいこと。

【００５１】前記強磁性層の厚さが３ｎｍ～２０ｎｍであること。

【００５２】前記第二の強磁性層が、ニッケル５０～８５原子%，鉄１５～２０原子%，残部はクロム，バナジウム，チタン，銅，金，銀，白金族，タンタル，ニオブ，ジルコニウム及びハフニウムからなる群から選択された少なくとも一つを合計で３５%以下含有し、飽和磁束密度が０．９ テスラ以下であること。

【００５３】前記第一および第三の強磁性層の少なくとも一方が、Ｃｏを主成分とする飽和磁束密度が１．０ テスラ以上の磁性体からなること。

【００５４】前記Ｃｒ合金反強磁性膜が、体心立方構造もしくはＣｓＣｌ型構造の結晶格子を０．１ から１０%の範囲で歪ませた構造を有すること。

【００５５】上記Ｃｒ合金反強磁性膜を歪ませる熱処理を行うこと。

【００５６】前記Ｃｏ合金が、Ｃｏ，ＮｉおよびＦｅからなり、その組成が、Ｃｏ３０から９８原子%，Ｎｉ０から３０原子%，Ｆｅ２から５０原子%であって、特に、Ｃｏ８５から９５原子%，Ｆｅ５から１５原子%であるか、またはＣｏ５０から７０原子%，Ｎｉ１０から３０原子%，Ｆｅ５から２０原子%であること。

【００５７】前記Ｃｏ合金が、Ｃｏ，Ｎｉ，Ｆｅおよび添加元素Ｘからなり、Ｃｏ，Ｎｉ，Ｆｅの合計が７０から９８原子%，Ｘが２から３０原子%であって、上記ＸがＣｕ，Ｃｒ，Ｖ，Ｔｉ，Ｔａ，Ｎｂ，Ｚｒ，Ｈｆおよび白金族のいずれか一つまたは複数であること。

【００５８】上記Ｃｒ合金反強磁性膜表面上に熱処理，薄膜形成技術、またはイオン打ち込みなどによって酸化膜を形成してなること。

【００５９】前記強磁性体の第２磁性層の磁化方向を固定する前記手段が、前記強磁性体の第１磁性層よりも高い飽和保磁力を有する前記強磁性体の第２磁性層であること。

【００６０】前記強磁性体の第２磁性層の磁化方向を固定する前記手段が、前記強磁性体の第２磁性層に直接に接触する反強磁性層を有すること。

【００６１】前記強磁性体の第２磁性層の磁化方向を固定する前記手段が、前記強磁性体の第２磁性層に直接に接触する硬質強磁性層を有すること。

【００６２】異方性磁気抵抗が、個々の前記強磁性体の磁性層の磁化の回転によって生じる前記磁気抵抗効果素子の前記電気抵抗変化に加えられるように、前記電流の方向に対する個々の前記強磁性体の薄膜層の磁化方向が定められていること。

【００６３】異方性磁気抵抗が、前記強磁性体の第１磁性層の磁化の回転によって生じる前記磁気抵抗効果素子の前記電気抵抗変化に加えられるように、前記電流の方向に対する個々の前記強磁性体の薄膜層の磁化方向が定められていること。

【００６４】前記強磁性体の第１磁性層を単一のドメイン状態に保持するのに十分な縦方向のバイアスを生じさせる手段をさらに有すること。

【００６５】縦方向のバイアスを生じさせる前記手段が、前記強磁性体の第１磁性層の端部領域だけに、直接に接触する反強磁性層を有すること。

【００６６】縦方向のバイアスを生じさせる前記手段が、前記強磁性体の第１磁性層の端部領域だけに、直接に接触する硬質強磁性層を有すること。

【００６７】前記強磁性体の第１磁性層を単一のドメイン状態に保持するのに十分な縦方向のバイアスを生じさせる手段をさらに有すること。

【００６８】縦方向のバイアスを生じさせる前記手段が、前記強磁性体の第１磁性層の端部領域だけに、直接に接触する反強磁性層を有すること。

【００６９】縦方向のバイアスを生じさせる前記手段が、前記強磁性体の第１磁性層の端部領域だけに、直接に接触する硬質強磁性層を有すること。

【００７０】

【発明の実施の形態】

（実施例１）図１～図５は磁気ヘッドをしゅう動面側からみた時の記録ヘッド部付近の構造を示したものである。上部シールド膜となる下部磁性膜５の下にはＭＲやＧＭＲ膜があり、再生ヘッド部分となる。基板は表面凹凸（５ｎｍ以下）の小さなものが望ましい。

【００７１】図１に示すように、下部磁性膜の一部１１にスパッタリング法やイオンビームスパッタリング法で高比抵抗（８０μΩｃｍ以上）、Ｂｓ＞１．５Ｔ、の膜を作成し、その上に０．１ないし０．２μｍの非磁性膜をスパッタリング法で形成し、ギャップ膜４とする。この特性を満足する磁性膜にはＦｅ，ＣｏＦｅあるいはＣｏＮｉＦｅ合金に酸素や窒素を添加し、酸素や窒素と親和力の強い元素を同時に添加すること又は、Al_2O_3，SiO_2 等の酸化物や窒化物と強磁性膜を積層することで、高比抵抗膜を実現できる。また、磁歪定数は他の添加元素（例えば３ｄ遷移金属）又は母合金組成の調整により、制御可能であり、酸素や窒素濃度にも依存する。この高比抵抗膜の上にめっき膜の下地３をスパッタリング法により形成する。下地３は上述した材料とすることにより高比抵抗膜とすることも可能であり、膜厚が１００ｎｍ以下である。下地３の上にレジストフレーム２を形成し、めっき法で上部磁性膜１を作製する。トラック幅はフレームの間隔で決まり、フレームめっき法では０．５μｍ まで組成変動なく作製できることを確認しており、トラック幅は０．５ないし１．５μｍのヘッドを作成した。レジストフレームはＲＩＥ(リアクティブイオンエッチング)法でSiO_2 等の酸化物をマスクにして作製する。フレームめっき法では比抵抗が６０μΩｃｍ以下

15

のＦｅ，ＮｉＦｅ，ＣｏＦｅ、あるいはＣｏＮｉＦｅを主成分とする合金膜である。このめっき法で作成する上部磁性膜の一部を高比抵抗膜とし、図５に示す構造としても良い。上部磁性膜１をマスクとしてミリングやＲＩＥ法により、下地３やギャップ膜４及び下部磁性膜１１（ＭＲやＧＭＲの上部シールド膜）の一部を再付着なしで除去（トリミング）することにより、サイドフリンジを低減することが可能である。ＲＩＥ法を用いる場合はガス種やガス圧、エッチング速度を最適化することにより、上部磁性膜１をマスクにしてほぼ垂直にエッチング可能である。高比抵抗膜の膜厚は、ギャップ膜の膜厚の０．５ ないし３倍以上とすることで、高周波数における、記録性能の低下を抑制できる。上部磁性膜１の膜厚は２ないし３μｍであり、上部磁性膜１すべてを高比抵抗のめっき膜とすることは困難である。その理由は、めっき膜で特性（高ρ，低Ｈｋ，低λ）を全て満足する膜は膜応力が大きく、高抵抗のための種々の添加物やめっき浴の安定化のための添加剤を使用するためめっき浴の管理が困難であること、添加するとＢｓが低下すること、及び磁歪の調整がスパッタリング法よりも困難であることである。そこで上部磁性膜の一部を高比抵抗上部磁性膜１２で作成した図５に示す構造の記録ヘッドを作製することができる。

【００７２】図３に示すように、ギャップ４の上下の膜（下部磁性膜５及び上部磁性膜１）をめっき法で作製し、フレームの一部の上と上部磁性膜１上に高比抵抗上部磁性膜１２をスパッタリング法で作製することが可能である。この場合、ギャップ膜は導電性非磁性膜（ＣｒＮｉ合金，ＣｒＣｕ合金等のＣｒ合金，ＮｉＷ合金，貴金属合金等）である。また、フレームはSiO_2 等の酸化物であり、図１のようにフレーム除去工程はなく、フレームがそのまま浮上面に残る。フレーム形成にはＲＩＥ法を用いる。又はレジストフレームを用いてめっき膜形成後、フレームを除去し、高Ｂｓの下部磁性膜５，ギャップ膜４及び上部磁性膜１をフレーム間隔とほぼ同じ幅で作製できる。また、フレームの高さは上部磁性膜１，下部磁性膜５及びギャップ膜４の合計膜厚に近い値で良い。上部磁性膜１と下部磁性膜５の膜厚はギャップ膜の膜厚の約３倍以下である。

【００７３】図３と類似構造の記録ヘッドとして図２に示すように、ギャップ４と下地膜３までをスパッタリング法で作製後、フレームをSiO_2 等の酸化物で作製し、上部磁性膜には低比抵抗の強磁性膜をめっき法で形成し、さらに図３と同様に、フレームの一部の上と上部磁性膜１上に高比抵抗上部磁性膜１２をスパッタリング法で作製する。高比抵抗膜のＢｓはめっき法で作製した上部磁性膜１のＢｓより小さい。高比抵抗とするために酸化物等の混相厚又は酸化物膜との多層膜となっているため上部磁性膜１のＢｓよりも小さくなる。この場合は下部磁性膜５が上部磁性膜１の幅（トラック幅）よりも

16

広いため、サイドフリンジが他の方法よりも大きくなる可能性がある。

【００７４】図４は図１と類似の構造であるが、ギャップ４の上にもめっきで薄い高比抵抗上部磁性膜１２を形成している。膜厚はギャップの０．５ ないし３倍であり、この範囲の膜厚であれば、高比抵抗の効果が明瞭に記録性能に表れると共に、めっきも可能である。このめっき膜からなる高比抵抗上部磁性膜１２はＰ，Ｂ，Ｏ等の元素を含む強磁性合金膜であり、上述のスパッタリング法で形成されている高比抵抗膜の比抵抗値よりも小さい比抵抗（６０μΩｃｍ）である。さらに、図５に示すようにスパッタリング法を用いて上部シールド膜１１の一部及び上部磁性膜１２の一部を高比抵抗（８０μΩｃｍ以上）膜とすることも可能である。

【００７５】図５は浮上面から見た記録ヘッドの構造であり、このヘッドを浮上面から垂直方向に切断した面の構造は図６（５）となる。下部磁極及び上部磁極が多層構造となっており、ギャップ膜５と接触した上下磁性膜１３，１４はめっき法で作製できる。上下磁性膜１３，１４はＮｉＦｅ合金，ＣｏＮｉＦｅ－（Ｐｔ，Ｐｄ）合金あるいはこれらの合金に３ｄ遷移金属元素を添加した膜である。ギャップ膜は上下磁性膜と同じフレームを用いて作製できる。上下磁性膜１３，１４の磁気特性はＢｓが１．０Ｔ 以上、比抵抗は６０μΩｃｍ以下、Ｈｋが２０　Ｏｅ以下、磁歪定数（λ）が1×10^{-5}以下である。上下磁性膜１３，１４の膜厚はいずれもギャップ膜の３倍以上であり、ギャップ膜の膜厚は０．１μｍ である。ギャップ膜の材料は比磁性導電膜であり、ＣｒＮｉ合金，ＣｕＣｒ合金，ＮｉＷ合金あるいは貴金属膜である。高比抵抗磁性膜１１，１２はスパッタリング法で作製でき、ＮｉＦｅとAl_2O_3膜の積層膜，ＮｉＦｅ膜とAl_2O_3膜の混相膜あるいはＮｉＦｅＮとAl_2O_3の混相膜あるいはＮｉＦｅＮとAl_2O_3の多層膜等であり、膜の比抵抗が上記上下磁性膜１３，１４よりも高くなるように組成や膜構成を制御する。比抵抗を高くするためには、上記のように多層化あるいは混層化の手法を用いるため、膜の飽和磁束密度が低下し、めっき法で作製する上下磁性膜よりも小さくなる。すなわち、ギャップに接触している上下磁性膜１３，１４の飽和磁束密度の方が高比抵抗膜よりも高くなる。浮上面のギャップ上の磁界強度を高くするためには本実施例のように高飽和磁束密度膜をギャップ膜近傍にする方が良い。高比抵抗膜１２の膜厚は約３μｍである。また高比抵抗上部磁性膜１２，高比抵抗下部磁性膜１１の幅は上下磁性膜１３，１４の膜よりも約０．５ から１μｍ広く、上下磁性膜の幅は約０．５μｍ である。めっきにはSiO_2 のフレームを用いる以外にレジストフレームを用いめっき後にレジスト除去後、上下磁性膜１３，１４以外の部分を保護膜（Al_2O_3やSiO_2 等）で覆い、上下磁性膜と保護膜上に広い幅の高比抵抗強磁性膜を形成すれば良い。図６

17

の（5）ではコイルが2層となっているが1層でも良い。

【0076】図6に記録ヘッドの摺動面から垂直方向の切断面を示す。（1），（2），（3），（4），（5）はそれぞれ図1，図2，図3，図4，図5に対応する切断面を示している。（1）では上部磁性膜が1層の磁性膜からなり、下部磁性膜が2層の磁性膜から構成され、下部磁性膜のギャップ膜56に近い磁性膜が高比抵抗膜となっている。ギャップ膜56の上には絶縁膜中にコイル55があり、コイルに電流を流すことにより、浮上面から磁界を発生させる。（2）の構造は下部磁性膜が1層、上部磁性膜が2層構造となっており、上部磁性膜のギャップ膜56に近い磁性膜を高飽和磁束密度低比抵抗膜51とする。この高飽和磁束密度低比抵抗膜はメッキ法で作製し、この磁性膜の幅がトラック幅を決定する。高飽和磁束密度低比抵抗膜は上部磁性膜の浮上面側のみに形成され、浮上面側から見た高飽和磁束密度低比抵抗膜の幅は高比抵抗磁性膜52よりも図2に示すように狭い。(1)の構造よりも（2）の構造のほうが狭トラックを容易に形成できる。(3)は下部磁性膜及び上部磁性膜が2層の磁性膜から構成されている。下部磁性膜は高飽和磁束密度低比抵抗膜51とその下の強磁性膜54から構成され、上部磁性膜は高飽和磁束密度低比抵抗膜51と高比抵抗磁性膜52から構成されている。高飽和磁束密度低比抵抗膜51とギャップ膜56はめっき法で作製し、高比抵抗磁性膜52はスパッタリング法で作製する。

（3）及び（5）の構造では、ギャップ膜56の上下に高飽和磁束密度低比抵抗膜を用いその浮上面から見た幅が他の磁性膜の幅よりも狭くすることができるので、狭トラックの記録ヘッドに有効な構造であり、ギャップ近傍に高飽和磁束密度膜を使用しているため、磁界強度を高くすることができ、高比抵抗の磁性膜を用いているため高周波特性も良好である。（4）は高飽和磁束密度膜51がギャップ膜56の上下の磁極全体に形成したものであり、浮上面のみ、図4のように狭トラック加工すれば、（3）及び（5）のように浮上面側のみめっき法で形成するプロセスを使用しなくても良い。(5)は（3）と類似した構造になっているが、ギャップ膜56に接触した高飽和磁束密度低比抵抗膜を用い、ギャップから離れた上下の磁極材料に高比抵抗磁性膜52を用いており、高周波特性が良好かつ1.0μm 以下の狭トラック化が可能である。図6において、高飽和磁束密度低比抵抗膜51は、それぞれの記録ヘッドにおいて他の部分に用いている磁極材料よりも飽和磁束密度が高くかつ比抵抗が他の磁極部分の材料よりも小さい材料である。高飽和磁束密度低比抵抗膜51に用いる材料は例えば、CoNiFe合金，NiFe合金あるいはこれらの合金に3d遷移金属元素を添加した材料である。ギャップ膜56にはメッキ法で作製する場合には非磁性導電膜を、その他の方法で作製する場合にはAl_2O_3やSiO_2等の酸化物

18

あるいは窒化物，炭化物、あるいはこれらの混相でも良い。

【0077】図7には図6と類似した構造の記録ヘッドの構造例を示す。（1）では高比抵抗磁性膜52をギャップ膜56から離れた上下の磁性膜を用いており、磁気ギャップ側には、高比抵抗磁性膜52よりも比抵抗の小さな強磁性膜54を用いている。高比抵抗磁性膜52の体積は低比抵抗の強磁性膜54の体積よりも大きく、高周波特性が高比抵抗膜を用いない場合よりも改善される。（2）ギャップ膜とギャップ膜に接触した磁性膜を狭トラックで形成し、その上の磁性膜を高比抵抗磁性膜52とすることにより、狭トラックかつ高周波特性の良好な記録ヘッドを提供することができる。（3）は上部磁性膜が3層となっており、ギャップ膜56は平坦部に作製しその上に幅の狭い磁性膜を介して、高比抵抗磁性膜52を形成する。高比抵抗磁性膜52の上には低比抵抗の強磁性膜54があり、この低比抵抗の強磁性膜54の飽和磁束密度を高くすることにより、浮上面の磁界強度を高くすることが可能である。（3）は類似した構造が（4）の記録ヘッドであり、上部磁性膜が3層構造となっているがギャップ膜56に近い部分を低比抵抗の強磁性膜54にギャップ膜から離れた部分を高比抵抗磁性膜52にすることで、(3)よりもギャップ近傍の材料の飽和磁束密度を高くすることができるで、（3）よりも磁界強度が高いヘッドを提供することができる。

【0078】図8（a）は、本発明の新規構造を有する磁気ヘッドの断面を示す。

【0079】下部コア25及び上部コア27の間にはコイル26が包込まれている。コイル26は、厚さ2μmのAlないしはCuから構成されている。コイル26とコア25，27との電気的な絶縁を保持する目的で非磁性の絶縁材31が充填されている。

【0080】本発明の磁気ヘッドは、上部コア27と下部コア25の間に磁極部材32，33と共に絶縁性の非磁性膜からなる磁気ギャップ10が新たに挿入されており、それら部材によって磁気ギャップ（あるいは記録ギャップ）が形成される点に特徴がある。また、他の特徴に、上部コア27と下部コア25との間に磁路材41，42を設けた点がある。この構造は、本発明を実現する上での必須の構造ではない。磁路材41，42は上部コア27の平坦化を実現する上で好適であり、製造後に残るストレス（磁歪）の影響を低減する効果がある。同部材を磁極部材32，33と同時に形成することにより、製造コストの上昇を防ぐことができた。

【0081】同図（b）は上部コア側から磁気ヘッドを見た図である。コイル26が螺旋状に巻かれている様子がわかる。このコイル26は、コンタクトホール34にて電極30（図（a））と結合されている。また、上部コア27と下部コア25は、磁気的なコンタクトホール35にて結合されている。この磁気的なコンタクトホー

19

ル３５が先に示した磁路材４１，４２を含めた構成となっている。

【００８２】本発明の特徴である絶縁性の磁気ギャップ１０は、上部コア２７と下部コア２５の先端に位置し、一部が摺動面に露出する構造になっている。同部材の構造をα方向から見ると図（c）のようになる。すなわち、上部コア２７と下部コア２５の間に幅の狭い磁極部材３２，３３がはさみ込まれており、さらにこれら部材に挟まれた位置に絶縁性の非磁性膜からなる磁気ギャップ１０が存在する。磁極部材３２，３３は上部コア２７及び下部コア２５の先端磁極と磁気的にはそれぞれ一体となっている。このため、ギャップ部は互いに凸形状を有する磁極から構成されるごととなる。

【００８３】また、図（c）は上記磁気ヘッドが記録媒体と接近する面から見た磁極構造と一致しており、図から上部磁極が凸形状を有し、かつ、下部磁極に向かって凸部が形成されている様子がわかる。

【００８４】また、図（c）から、これら磁極が共に凸形状を有し、特に上部磁極の凸部と下部磁極の凸部の幅がほぼ等しいことがわかる。

【００８５】また、本発明の場合、凸部の高さを約０．８μm とした。また、凸部の幅は、１μmとした。この関係から、凸部の高さは、凸部の幅に比べ低くなる。

【００８６】本発明にて開示する構造は、磁路抵抗を下げられ、その原理を図９及び図１０を用いて述べる。図９は磁極部材３２，３３の無い特開平7－296328 号公報に記載の従来の磁気ヘッドの断面図を示す。図９は、下部コア２５と上部コア２７から挟まれた磁気ギャップを示している。媒体６１への書き込み磁束は、βと示す経路のように導かれる。しかし、高密度記録を達成するため、上部コア２７のギャップ先端側の幅（磁極幅）が狭められると、磁路抵抗が増加してしまい、この影響から、磁路抵抗の増加する領域５０にて磁束が経路αのように流れる現象が顕著となった。このため、ギャップ先端部５７に導かれる磁束量が減少してしまい、必要な磁束をギャップ（磁極）先端から取り出すことができなかった。

【００８７】これに対して、図１０に示す磁極部材３２，３３を有する磁気ヘッドの場合、上部コア２７と下部コア２５の間に磁極部材３２，３３が存在する。このため、これら部材の厚み分だけ経路αのパスを長くできる（非磁性体の領域を広くできる）。この効果から、磁極幅を狭めることによって磁路抵抗が増加しても、経路αを流れる磁束量の増加を低く押さえることができる。

【００８８】上記効果は、１５０MHｚ以上の書き込み周波数でも認められた。これは、本発明が磁気ギャップに絶縁性非磁性膜を用いた効果である。また、磁極材料にＣｏＴａＺｒ等のアモルファスの高電気抵抗の磁性膜を用いた場合、書き込み周波数を２００MHｚまで高めることが出来た。

20

【００８９】特開平7－296328 号公報に開示される従来構造では、凸部となるトレンチ構造内が低電気抵抗材から構成されるため、この部分でうず電流が発生しやすく、書き込み周波数の上限は、１００MHｚに制限された。

【００９０】また図８の（c）に示したように、磁極部材３２，３３の幅ｗ１は上部磁極２７及び下部磁極２５の幅に比べ狭い。これは磁極形状が凸形状を有する所以でもある。この形状の効果から、対面する凸部に磁束が集中することは言うまでもない。したがって、コイル電流（書き込み電流）を調整し、凸部からの磁界と媒体の書き込みに必要となる磁界を一致させた条件では、凸部以外の（ギャップ寸法が広くなる）領域では書き込みが起きない。従って、書き込まれるトラックの幅を、凸部の幅とほぼ一致させることができる。

【００９１】さらに本発明では、凸部のみを高電気抵抗かつ高飽和磁化材料から構成することも可能であり、この効果から凸部の幅に相当する領域に強磁界を発生させることが出来る。この効果から、凸形状を有する磁極形状を有しても、書き込みトラック幅を凸部の幅に制限することが高効率に出来る。

【００９２】また、凸部の高さは、凸部の幅に比べ低いため、後に述べる工程を用いれば、凸部の幅を２μm以下にできる。この効果から、媒体に書き込みが行われる幅を容易に２μm以下にできる。

【００９３】さらに本発明の場合、書き込みが行われる幅が凸部の幅によって決定するため、高密度記録を実現する上で、上部コア２７の幅も下部コア２５の幅もあえて狭める必要は無い。この効果から磁路抵抗の増加が無く、必要磁界が高効率で磁極先端（ギャップ部）部に導くことができる。

【００９４】磁気ギャップに絶縁性非磁性膜を用いる従来の磁気ヘッドの場合、磁極を摺動面側から見ると形状は、図１１に示す３種類に大別される。それらは、

（a）に示す長さの異なる磁極２７，２５から構成されるものと（b）に示す長さの等しい磁極２７，２５から構成されるもの、さらに片側に突起を有する磁極２５が存在するものとなる。（b）は（a）の磁極構造を改良したもので、磁極の長さが等しいためトラック幅方向の漏洩磁界が少ない特徴を有する。このため、狭トラックの書き込みに有利と考えられている。しかし、この構造では、磁極２５を磁気抵抗効果素子に対するシールド層と兼用することができない欠点がある。この欠点を対策したものが（c）の構造である。

【００９５】図１１に示した（c）の構造において狭トラック化を実現するためには、幅Wを狭める必要がある。このため、図４に示した磁路抵抗の増加に伴う書き込み磁束の減少が生じる。このため、高密度の情報を高効率で書き込むことはできない。

【００９６】本発明の構造は、書き込みギャップ部の幅

21

が凸部の幅で制限されるため、図１１の（ｂ）に示した磁極と同様、トラック幅方向への漏洩磁界の広がりが少ない。このため、高密度記録に適する。さらに、下部コアの幅が凸部の幅より広いため、下部コアを磁気抵抗効果素子に対するシールド層と兼用することに何らの問題も生じない。

【００９７】以上述べたように本発明の磁気ヘッド構造は、従来技術の磁気ヘッドで問題となった高密度記録に関わる問題がまったく生じない。この優れた性能を実現する磁気ヘッドの製造工程を図１２を用いて述べる。

【００９８】同図は、図８（ｂ）に示した方向“α”から磁気コアの磁極先端が形成されていく様子を見たものである。図に沿って順に工程を述べる。

【００９９】まず工程（ａ）では、基板（あるいは下地層ないしは下地構造）７４の上に下部磁極を構成する下部磁性膜７３を積層した。磁性膜としては、Ｎｉ－Ｆｅ合金膜を用いた。厚みは２μｍとした。この上に絶縁性非磁性膜として厚さ０．３μｍのアルミナ膜７５を積層し、さらに厚さ０．８μｍ のＮｉ－Ｆｅ合金からなる磁性膜７２を積層した。積層を終えた後、凸部の幅（書き込みトラック幅に相当する）のレジストパターン７１をホトリソグラフィ法にて形成した。厚みは、１μｍとした。

【０１００】次いで工程（ｂ）では、レジストパターン７１をマスクに合金磁性膜７２をイオンミリング法にてエッチングし、上部磁極の突起部となる部分を形成した。しかる後、レジストパターン７１及びエッチングにより形成した上部磁極の突起部分をマスクにしてアルミナ膜を塩素系およびフッ素系の反応性ガスによりエッチングした。この後、再度、上部磁極の凸部分となる部材をマスクに下部磁極をイオンミリング法にてエッチングすることで下部磁極に凸部を形成した。この際のエッチング深さは０．８μｍ とした。上部磁極の凸部分となる部材をマスクに下部磁極をイオンミリング法にてエッチングすることで長さの揃った突起部を対面させることができる。これは、漏洩磁界のトラック幅方向への広がりを少なくする上で効果的であり、本発明を機能させる上の重要な要素となる。

【０１０１】工程（ｃ）では非磁性かつ絶縁性の非磁性膜７６を全面に積層した後、積層した非磁性かつ絶縁性膜を平坦化処理すると共に、凸部となる磁性膜７２の一部を露出させた。この工程は、例えば、半導体等の製造に使われている流動性のある熱硬化型絶縁材（スピンオングラスとも呼ばれる）を塗布した後、所定の熱処理を施し、さらに基板表面を機械的にラッピング処理することで実現できる。他にレジストの熱流動性を用いても容易に形成することができる。

【０１０２】本発明を実現する上で凸部となる磁性膜７２が絶縁層から露出することが必要条件である。これを実現出来る工程であれば、あえて、絶縁層の平坦化処理

22

は不要であり、例えば絶縁材７６の厚みが凸部となる磁性膜７２の厚みを越えるような状態でも本発明に何らの問題も来さないことを確認している。この様な極端な場合（絶縁材７６の厚みが凸部となる磁性膜７２の厚みを越えるような状態）、上部磁極にうねりが生じ、谷となる部分に突起部が存在することとなる。この構造に関しては、別に述べる。

【０１０３】最後に工程（ｄ）にて上部磁極部材を構成する残りの部材を形成した。上部磁極材としては、これまでと同様、Ｎｉ－Ｆｅ合金膜を用いた。

【０１０４】以上述べた工程により、図８（ｃ）に示した磁極構造が形成出来る。本実施例では、磁極材料としてはＮｉ－Ｆｅ合金膜を用いたが、他の軟磁性膜を用いても本実施例と同様の工程から、本発明の磁気ヘッドを形成することが出来た。特に高電気抵抗の軟磁性膜を用いることで高周波状態での書き込みを実現することが出来た。この軟磁性膜を電気メッキ法に依らず形成できる点が本発明の特徴であり、この効果から従来の磁気ヘッドを超える高周波書き込みが可能となる。

【０１０５】次に上部磁極に谷を有する構造について述べる。この構造は、下記工程を少なくとも含む磁気ヘッドの製造工程から製造出来る。先と同様、図１２を用いて述べる。

【０１０６】まず、（ａ）に示すように磁気ヘッド下地構造７４の上に下部磁極材７３を積層した後、アルミナからなる非磁性膜７５を積層し、さらに上部磁極の一部を構成する凸部となる磁性膜７２を積層した。

【０１０７】次に、上記積層構造の上にリソグラフィ法を用いて上部磁極の凸部に相当する領域にレジストパターン７１を形成した。

【０１０８】次いで（ｂ）に示すように上記レジストパターン７１並びに上部磁極の凸部分となる部材をマスクに絶縁性非磁性膜並びに下部磁極をエッチングすることで下部磁極に凸部を形成した。

【０１０９】この後、（ｃ）に示すように上部及び下部磁極にて凸部となる部材を形成した後、非磁性かつ絶縁性膜７６を凸部以外の領域に凸部を超える膜厚で積層した。図では絶縁性非磁性膜７６の表面と凸部の表面（７２の表面）が同一面にあるように表示されているが、本実施例では、絶縁性非磁性膜７６の厚みが凸部の表面（７２の表面）を超える。

【０１１０】しかる後、（ｄ）に示すように上部磁極材の残りである上部磁性膜７７を形成することで目的とする磁気ヘッド磁極形状を製造した。

【０１１１】図１３に上記工程を少なくとも含む工程から製造した磁気ヘッドの磁極形状を示す。図から、凸部に谷を有する上部磁性膜７７の形状が良くわかる。

【０１１２】この形状は、上部磁性膜の磁束を突起部に高効率に引き込む上で高効率であったことを明記しておく。

23

【０１１３】本発明の磁気ヘッドは、アルミナとチタンカーバイドとの焼結体を機械加工したウエハ上に形成した。この後、所定の機械加工を施し、磁気ヘッドスライダーを製造した。

【０１１４】上記工程によれば、書き込みトラック幅を規定する突起部の幅はレジストパターンの幅によって決まる。しかし本発明の磁極突起部の高さは、突起部の幅より低くすることで、あえて膜厚の厚いレジストパターンを必要としない。この効果から、メッキ用のマスクパターンとなるレジストパターンに比べ解像が容易であり、突起部の幅を２μm以下にすることできる。この特徴から狭トラック対応の磁気ヘッドを容易に製造できる。

【０１１５】同磁気ヘッドから構成されたヘッドスライダを用いることにより、トラック幅２μm以下の高密度記録を達成することが出来る。この効果から、従来不可能と考えられていた５Ｇｂ／ｉｎ^{2}以上の高密度磁気記録装置を実現することが出来る。これは、磁極先端部分まで高効率に磁束を導くことができた効果であり、この効果は、磁極先端を互いに突起を有する磁極から構成したことにより生まれた。

【０１１６】（実施例２）図１４は実施例１に記載の高比抵抗膜を記録ヘッドに用い、記録ヘッドと以下に示す再生ヘッドを組み合わせた記録再生ヘッドの一例を示している。再生ヘッドには巨大磁気抵抗効果膜１０４が用いられ、電流を流すための電極１０５が巨大磁気抵抗効果膜１０４に電気的に接触している。電極１０５及び巨大磁気抵抗効果膜１０４の下には下部ギャップ膜を介して下部シールド膜１０６がある。巨大磁気抵抗効果膜１０４の上には上部ギャップ膜を介して上部シールド膜となる高比抵抗下部磁性膜１０８があり、高比抵抗下部磁性膜１０８は記録ヘッドの下部磁極の一部となっている。この高比抵抗下部磁性膜１０８の一部を高比抵抗膜にして記録ヘッドの高周波特性を改善することが可能である。記録ヘッドのギャップ膜１０２はその上下の磁性膜と幅が等しく、上下の高飽和磁束密度膜１０１，１０３は他の磁極部分よりも高飽和磁束密度の材料が望ましい。この高飽和磁束密度膜１０１の上に幅の広い高比抵抗上部磁性膜１０７を用いる。記録ヘッドのコイル１０９に電流を流し、記録ヘッドからの磁界により記録媒体１１０に記録される。尚、再生ヘッドは強磁性トンネル膜を用いた異なる構造のヘッドでも良い。

【０１１７】図１５は本発明の他の構造のスピンバルブ磁気抵抗効果膜を用いた磁気ヘッド（ＭＲセンサ）の部分断面図である。

【０１１８】本発明のＭＲセンサは、ガラス，セラミックのような適切な基板４３の上に、軟質強磁性体の第１磁性層４５，非磁性金属層２１、及び強磁性体の第２磁性層２２を付着させた構造である。強磁性層４５及び２２は、磁界が印加されていない場合は、個々の磁化方向

24

が約９０度の角度差になるようにする。さらに、第２磁性層２２の磁化方向は、磁性媒体の磁界方向と同じ方向に固定される。磁界が印加されていない場合の軟質強磁性体の第１磁性層４５の磁化方向は第２磁性層の磁界方向に対して９０度傾いている。印加された磁界に感応して第１磁性層４５に磁化回転が生じ変化する。

【０１１９】本実施例における第１磁性層４５，非磁性金属層２１，第２磁性層２２及び反強磁性体層２３は後述の図１６，図１７，図１８に示した積層構造で用いた膜構成を用いることができ、また、硬質強磁性層４７には$Co_{82}Cr_9Pt_9$，$Co_{80}Cr_8Pt_9(ZrO_2)_3$を用いることができる。これらの図１６，図１７及び図１８の膜構成は本実施例における第１磁性層４５と第２磁性層２２に相当する膜構成を有し、それらの磁界方向は前述と同様に形成されている。

【０１２０】本実施例では軟質強磁性体の第１磁性層４５の付着を行う前に、例えば、Ｔａ，Ｒｕ、又はＣｒＶのような適切な下部膜２４を基板４３の上に付着させる。下部膜２４を付着させる目的は、後に付着させる層の組織，結晶粒度、及び形態を最適化させるためである。層の形態は、大きなＭＲ効果を得るのに非常に重要である。それは層の形態によって非磁性金属層２１の非常に薄いスペーサ層を利用することができるからである。さらに分流による影響を最小にするために、下部層は高電気抵抗がよい。下部層は前述したように逆構造としても使用できる。基板４３は十分な高電気抵抗で、十分に平面であり、且つ適切な結晶構造の場合は、下部膜２４は不要である。

【０１２１】第１磁性層４５は、紙面に平行な方向に単一のドメイン状態に保持させるための縦方向にバイアスを生じさせる手段が用いられる。縦方向にバイアスを生じさせる手段は、高飽和保磁力，高直角度、且つ、高電気抵抗を有する硬質強磁性層４７が用いられる。硬質強磁性層４７は、軟質強磁性体の第１磁性層４５の端部の領域に接触している。硬質強磁性層４７の磁化方向は、紙面に平行である。

【０１２２】反強磁性層を第１磁性層４５の端部の領域に接触させて付着させることができ、必要な縦方向のバイアスを生じさせる。これらの反強磁性層は、強磁性体の第２磁性層２２の磁化方向を固定させるために用いられる反強磁性層２３よりも十分に異なるブロッキング温度を有するものが良い。

【０１２３】次に、例えば、Ｔａのような高抵抗の材料のキャッピング層が、ＭＲセンサ上部全体に付着させられるのが好ましい。電極２８が備えられ、ＭＲセンサ構造体と電流源及び検知手段間に回路が形成される。

【０１２４】図１６～図１８は図１５の非磁性金属層２１，第２磁性層２２及び反強磁性体層２３の各膜に代えて形成した本発明の磁気抵抗効果素子を構成する膜で、高周波マグネトロンスパッタリング装置により以下のよ

25

うに作製した。アルゴン３ミリトールの雰囲気中にて、厚さ１ミリ，直径３インチのセラミックス基板に以下の材料を順次積層して作製した。スパッタリングターゲットとしてタンタル，ニッケル－２０ａｔ％鉄合金，銅，コバルト，クロム－５０ａｔ％マンガンの各ターゲットを用いた。クロム－マンガン合金膜の作製では、クロム－マンガンターゲット上に添加元素の１センチ角のチップを配置し、チップの数を増加あるいは減少させることで組成を調整した。また、強磁性膜としてＣｏ－Ｆｅ－Ｎｉ層を作るときはコバルトターゲット上にニッケル，鉄の１センチ角のチップを配置して組成を調整した。

26

【０１２５】積層膜は、各ターゲットを配置したカソードに各々高周波電力を印加して装置内にプラズマを発生させておき、各カソードごとに配置されたシャッターを一つずつ開閉して順次各層を形成した。膜形成時には永久磁石を用いて基板に平行におよそ３００Ｏｅの磁界を印加して、一軸異方性をもたせるとともに、クロム－マンガン膜の交換結合磁界の方向を印加磁界の方向に誘導した層の形成条件の一例を表１に示す。

【０１２６】

【表１】

表　１

積層膜形成条件例

層	Ａｒガス圧力	ｒｆ出力	形成速度
Ｔａ：	０．８ｍＴｏｒｒ	３００Ｗ	０．２５ｎｍ／ｓ
ＮｉＦｅ：	３ｍＴｏｒｒ	３５０Ｗ	０．１７ｎｍ／ｓ
Ｃｕ：	３ｍＴｏｒｒ	１５０Ｗ	０．２ｎｍ／ｓ
ＣｒＭｎＰｔ：	８ｍＴｏｒｒ	３５０Ｗ	０．５ｎｍ／ｓ
Ｃｏ：	３ｍＴｏｒｒ	２５０Ｗ	０．１３ｎｍ／ｓ

【０１２７】積層膜は、形成後に真空熱処理装置内において熱処理を行った。熱処理は、室温から、所定の温度、たとえば２５０℃まで昇温し、所定の時間、例えば１時間保持し、室温まで冷却して行った。上記昇温，保持、および冷却の全行程において、基板の面内に平行に２から５キロＯｅの磁界を印加して行った。上記磁界の方向は、膜形成時に永久磁石にて印加した磁界と平行な方向とした。

【０１２８】基体上の素子の形成はフォトレジスト工程によってパターニングした。その後、基体はスライダーに加工し、磁気記録装置に搭載した。

【０１２９】図１６は４５ａｔ％クロム－４５ａｔ％マンガン－１０ａｔ％白金の反強磁性膜／８１ａｔ％Ｎｉ－１９ａｔ％Ｆｅ膜を用いた磁性積層体を有するスピンバルブ膜の熱処理前と、熱処理後の特性を比較した図である。一方向異方性による結合磁界は図中の右側のループのシフト量として現われる。熱処理前の結合磁界は３００Ｏｅ，２５０℃，３時間の熱処理後でも３８００ｅである。これはＮｉＦｅ層の厚さおよび磁化の大きさを考慮すると、公知例で示されているのと同程度の大きさである。

【０１３０】図１７は４５ａｔ％クロム－４５ａｔ％マンガン－１０ａｔ％白金の反強磁性膜／Ｃｏ膜を用いた磁性積層体を有するスピンバルブ膜の熱処理前と、熱処理後の特性を比較した図である。熱処理前の結合磁界は３００Ｏｅで、図１の場合とほぼ同様であるが、２５０℃，３時間の熱処理後では結合磁界が６０００ｅと２倍程度に大きくなっている。これはＣｏ層の厚さおよび磁化の大きさを考慮すると、図１で示されている結合磁界の２倍程度の大きさである。

【０１３１】図１８は本発明の磁性積層体をスピンバルブ磁気抵抗効果膜として用いた場合の別の構成例で、反強磁性膜３０（４５ａｔ％Ｃｒ－４５ａｔ％Ｍｎ－１０ａｔ％Ｐｔ）と密着する強磁性層６５は、反強磁性膜３０と直接接合するＣｏ層111，磁気特性の良好な軟磁性層１１２（８１ａｔ％Ｎｉ－１９ａｔ％Ｆｅ），非磁性層６２（Ｃｕ）と直接接し、巨大磁気抵抗効果を生じるＣｏ層１１３からなっている。下地膜６４は他の膜の配向や結晶粒径を制御する下地層，軟磁性層６３（８１ａｔ％Ｎｉ－１９ａｔ％Ｆｅ）は自由層である。すなわち、反強磁性膜との接合部、および非磁性膜との接合部にＣｏ層を配置し、しかしながら固定層である強磁性層６５の磁気特性を劣化させず、かつ、層全体の磁化の量をあまり増大させずに強磁性層６５の厚さと特性を保つことができる。従って軟磁性層１１２は、磁気特性が良好で、飽和磁束密度がＣｏからなる層１１３および１１１より小さいことが望ましく、例えば飽和磁束密度が１テスラである$Ni_{81}Fe_{19}$膜である。あるいはさらに飽和磁束密度を低下させて０．５ テスラ程度でも良く、例えばＮｉＦｅ－Ｃｒ膜なども適当であり、このＮｉＦｅ－Ｃｒ膜は、０～２０ａｔ％Ｃｒを含有するＮｉＦｅ合金からなり、ＮｉＦｅ合金は７５～９５ａｔ％Ｎｉと残部Ｆｅとからなる。

【０１３２】（実施例３）図１９は実施例２に示した記録再生分離型ヘッドを用いた磁気ディスク装置の全体図である。記録再生分離型磁気ヘッド２０１はモータで回転する記録媒体２０３である磁気ディスクの上でヘッド位置決め機構２０２により記録媒体203上での位置が制御され、記録再生分離型磁気ヘッド２０１は再生信号処理系204と接続されている。

27

【０１３３】本装置において、磁気ディスクを回転するＤＣモータ，情報を書き込み，読み取りするための磁気ヘッド，これを支持して磁気ディスクに対して位置を変える手段の位置決め装置、即ち、アクチュエータとボイスコイルモータ、及び装置内部を清浄に保つためのエアフィルタなどからなる。アクチュエータは、キャリッジとレール，軸受からなり、ボイスコイルモータはボイスコイル，マグネットからなる。これらの図では、同一の回転軸に８枚の磁気ディスクを取付け、合計の記憶容量を大きくした例を示している。

【０１３４】磁気ディスクは表面粗さR_{MAX}が１００Å以下、望ましくは５０Å以下の表面性の良好な媒体とする。磁気ディスクは、剛性基体の表面に真空成膜法によって磁気記録層を形成してある。磁気記録層は磁性薄膜が用いられる。真空成膜法によって形成される磁気記録層の膜厚は０．５μｍ 以下であるので、剛性基体の表面性がそのまま記録層の表面性として反映される。従って、剛性基体は、表面粗さR_{MAX}が１００Å以下のものを使用する。そのような剛性基体としては、ガラス，化学強化されたソーダアルミノ珪酸ガラスまたはセラミックを主成分とする剛性基体が適している。

【０１３５】また、磁性層が金属や合金などの場合には、表面に酸化物層，窒化物層を設けるか、表面を酸化皮膜とするのが望ましい。また、炭素保護膜の使用等も望ましい。こうすることにより、磁気記録層の耐久性が向上し、極く低浮上量で記録再生する場合や、コンタクト，スタート，ストップ時においても、磁気ディスクの損傷を防止できる。

【０１３６】このような構成で評価した本発明による記録ヘッドの性能（オーバーライト特性）を測定した結果、４０ＭＨｚ以上の高周波領域でも－５０ｄＢ程度の優れた記録性能が得られた。

【０１３７】本実施例によれば、高保磁力媒体に対しても、高周波領域でも十分に記録可能であり、メディア転送速度１５ＭＢ／秒以上，記録周波数４５ＭＨｚ以上，磁気ディスク４０００rpm 以上のデータの高速転送，アクセス時間の短縮，記録容量の増大と、異方性磁気抵抗効果を基礎として優れたＭＲ効果を有する高感度のＭＲセンサが得られることから面記録密度として３Ｇｂ／in^2以上との磁気ディスク装置が得られるものである。

【０１３８】

【発明の効果】本発明によれば、記録ヘッドの磁極の一部を高比抵抗膜で作成し、高周波数において記録性能が低下しにくくできるため高記録密度の磁気記憶装置が得られる。

【０１３９】更に、本発明によれば十分な結合磁界と高い温度安定性を有した磁性積層体を提供でき、ひいては充分な再生出力と低ノイズ特性を有する再生ヘッドおよび高信頼性の高密度磁気記憶装置を得ることができる。

【図面の簡単な説明】

【図１】高比抵抗膜を下部磁性膜の一部に用いた記録ヘッドの浮上面から見た説明図。

【図２】高比抵抗膜を上部磁性膜の一部に用いた記録ヘッドの浮上面から見た説明図。

【図３】高比抵抗膜を上部磁性膜の一部に用いた記録ヘッドの浮上面から見た説明図。

【図４】高比抵抗膜を下部及び上部磁性膜の一部に用いた記録ヘッドの浮上面から見た説明図。

【図５】高比抵抗膜を下部及び上部磁性膜の一部に用いた記録ヘッドの浮上面から見た説明図。

【図６】高比抵抗膜及び高飽和磁束密度膜を磁極の一部に用いた記録ヘッドの浮上面に垂直なヘッド断面図。

【図７】高比抵抗膜を磁極の一部に用いた記録ヘッドの浮上面に垂直なヘッド断面図。

【図８】本発明の磁気ヘッドを示す概念図。

【図９】従来の磁気ヘッドにおける問題をしめす説明図。

【図１０】本発明の効果をしめす説明図。

【図１１】従来の磁気ヘッドの摺動面側から見た磁極形状。

【図１２】本発明の磁気ヘッドの主要部の作製工程図。

【図１３】本発明の磁気ヘッドの主要部の作製工程図。

【図１４】本発明の高比抵抗膜あるいは高飽和磁束密度膜を磁極の一部に用いた記録再生ヘッド。

【図１５】本発明に係るスピンバルブ型磁気ヘッドの磁気抵抗効果素子感磁部の斜視図。

【図１６】本発明に係るクロムーマンガン合金膜／ＮｉＦｅを用いたスピンバルブ膜の構成図。

【図１７】本発明に係るクロムーマンガン合金膜／Ｃｏを用いたスピンバルブ膜の構成図。

【図１８】本発明に係るスピンバルブ磁気抵抗効果膜との構成図。

【図１９】本発明の記録再生ヘッドを用いた磁気ディスク装置。

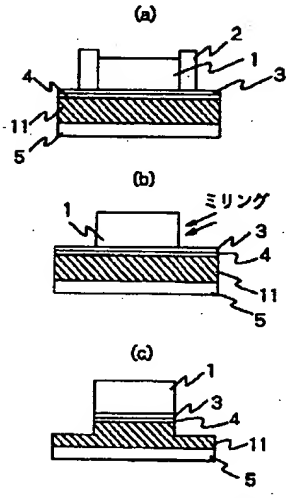
【符号の説明】

１…上部磁性膜、２…フレーム、３…めっき下地膜、４，５６，１０２…ギャップ膜、５…下部磁性膜、６…SiO_2フレーム、１０…磁気ギャップ、１１…高比抵抗下部磁性膜、１２…高比抵抗上部磁性膜、２１…非磁性金属層、２２…強磁性体の第２磁性層、２３…反強磁性層、２５…下部コアないしは下部磁極、２７…上部コアないしは上部磁極、２８…電極、３２，３３…磁極部材、４７…硬質強磁性層、５１…高飽和磁束密度低比抵抗膜、５２…高比抵抗磁性膜、５３…高比抵抗磁性膜、５４…強磁性膜、５５…コイル、６１，１１０，２０３…記録媒体、６２…非磁性層、６３…軟磁性層、６４…下地膜、６５…強磁性層、７１…レジストパターン、７２…磁性膜、７３…下部磁性膜、７５，７６…非磁性膜、７７…上部磁性膜、１０１…高飽和磁束密度膜、１０３…高飽和磁束密度膜、１０４…巨大磁気抵抗効果

膜、１０５…電極、１０６…下部シールド膜、１０７…高比抵抗上部磁性膜、１０８…高比抵抗（下部）磁性膜、１０９…コイル、２０１…記録再生分離型磁気ヘッド、２０２…ヘッド位置決め機構、２０４…再生信号処理系。

【図１】

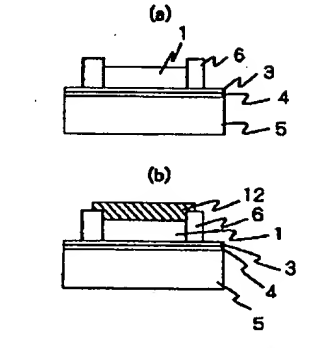
図 1



1…UP　2…フレーム　3…めっき下地
4…ギャップ　5…USL　11…USL（高比抵抗）

【図２】

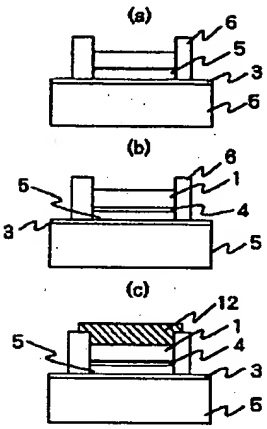
図 2



6…SiO_2フレーム　12…UP（高比抵抗）

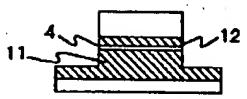
【図３】

図 3



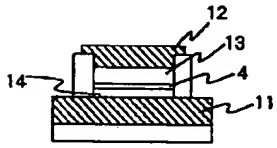
【図４】

図 4



【図５】

図 5



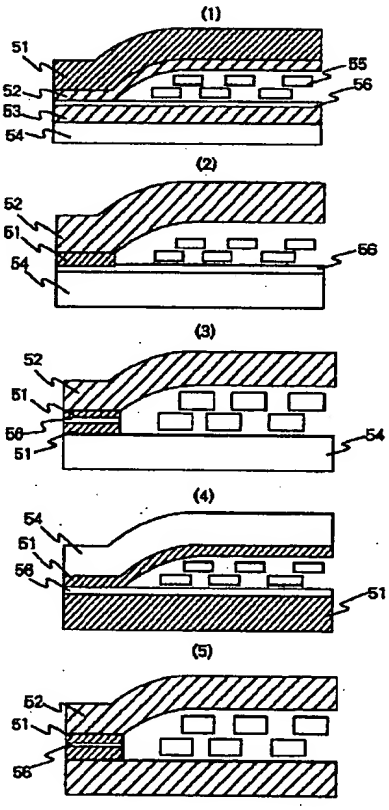
【図１６】

図 16

Ta (5nm)
$Cr_{45}Mn_{45}Pt_{10}$(30 nm)
$Ni_{81}Fe_{19}$ (3nm)
Cu (2.5nm)
$Ni_{81}Fe_{19}$ (5nm)
Ta (5nm)
glass

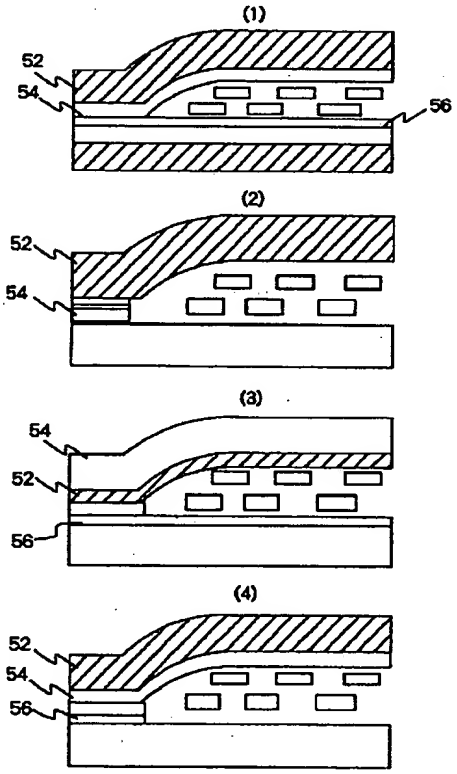
【図６】

図 6



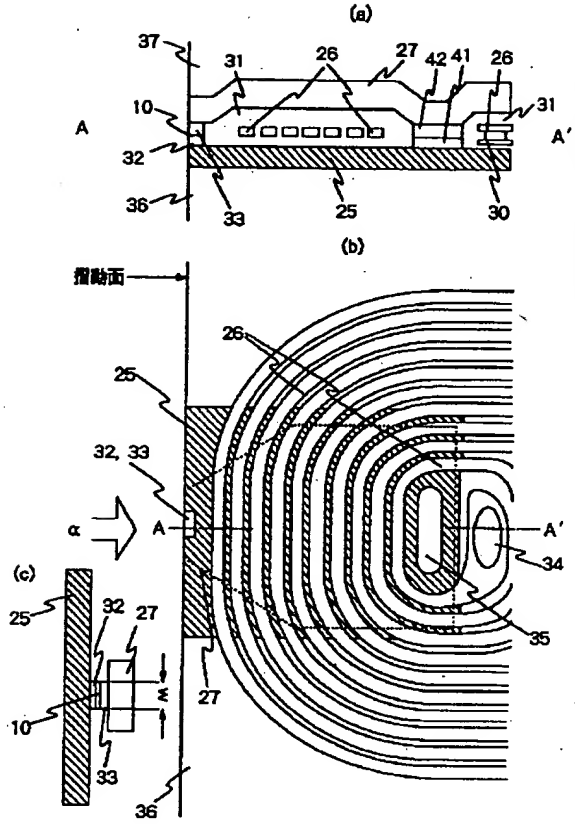
【図７】

図 7



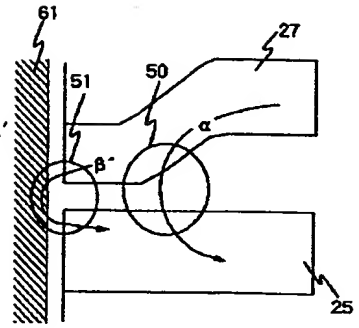
【図８】

図 8



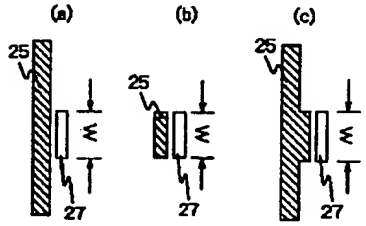
【図９】

図 9



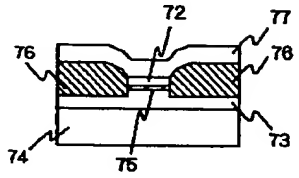
【図１１】

図 11



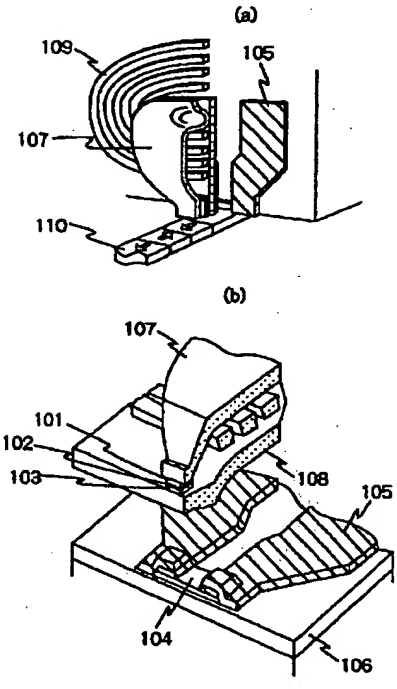
【図１３】

図 13



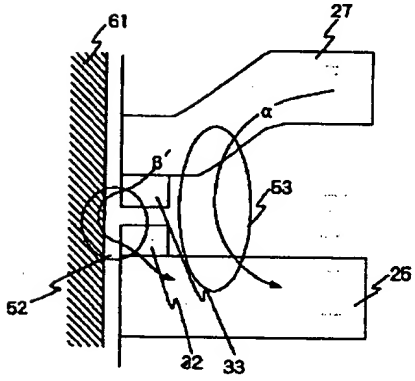
【図１４】

図 14



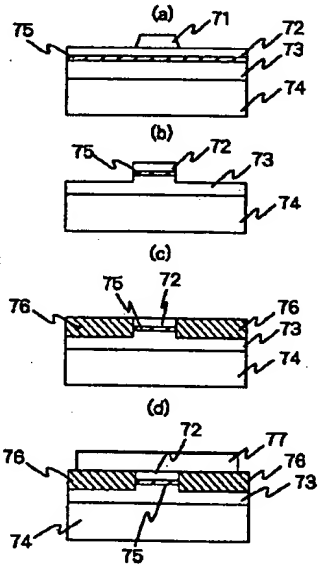
【図１０】

図 10



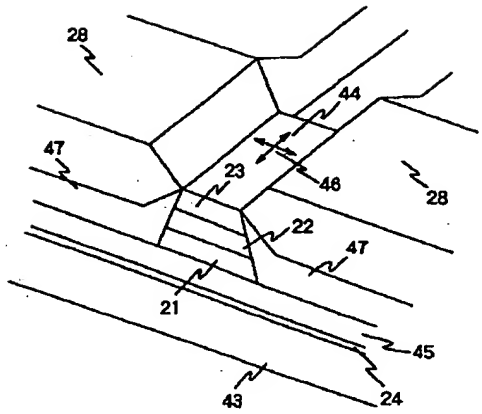
【図１２】

図 12



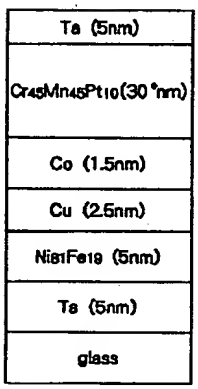
【図１５】

図 15



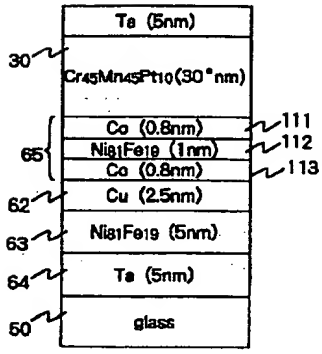
【図１７】

図 17



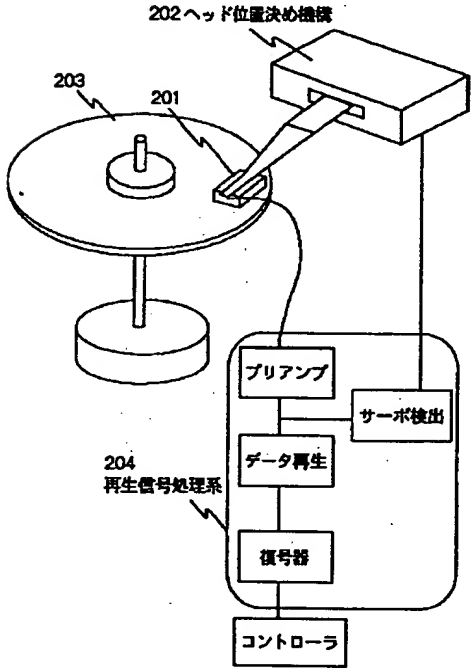
【図１８】

図 18



【図１９】

図 19



フロントページの続き

(72) 発明者　中村　敦
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内

(72) 発明者　清水　昇
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内

(72) 発明者　原　美紀
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内

(72) 発明者　川邊　隆
神奈川県小田原市国府津2880番地　株式会社日立製作所ストレージシステム事業部内

(72) 発明者　岡田　智弘
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72) 発明者　佐野　雅章
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72) 発明者　丸山　洋治
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72) 発明者　府山　盛明
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内
(72) 発明者　福井　宏
東京都国分寺市東恋ケ窪一丁目280番地
株式会社日立製作所中央研究所内